Dynamic Revenue Analysis Model

1 Introduction

In August of 1994 the California Legislature passed Senate Bill 1837 (S.B. 1837) which required the Department of Finance (DOF) to conduct a dynamic revenue analysis on all proposed legislation expected to have an annual fiscal impact of $10 million or more. To comply with the requirements of S.B. 1837, the DOF developed a Computable General Equilibrium (CGE) model of the California economy: the Dynamic Revenue Analysis Model (DRAM). The requirements of this law ended in January 2000. However, the DOF is maintaining DRAM as an analytical tool for future policy questions. This user's guide is a work in progress. It was prepared to broaden the accessibility of this model for researchers inside and outside the DOF.[1]

Its sections are:

How to Use DRAM to Analyze Bills: A frank description of how to use DRAM. This was written to maximize its accessibility. This section is a must read for people new to DRAM in particular or CGEs in general. It may seem out of order to explain how to use something before you explain what it is, but it was put at the front to make it easier to find.

Model Description: A general introduction to CGEs in general and DRAM in particular. This was written to maximize its accessibility.

Sensitivity Analysis Experiments: The set of experiments that have come to define DRAM's results over the years, again written to maximize its accessibility.

Guide to the Input File(s): The physical structure of the input files is explained in as simple terms as possible, but not as simple as the sections that precede it.

Model Data: The sources and, in some cases, the levels of data found in DRAM.

Equations: An equation-by-equation description of DRAM. This section is more technical than the ones before, but necessarily so given its content.

2 How to Use DRAM to Analyze Bills

2.1 General introduction.

This manual was prepared as a complement to rather than a substitute for other documentation of DRAM. Other documentation includes:

- Berck, Peter, Elise Golan and Bruce Smith, *Dynamic Revenue Analysis for California*, California Department of Finance, 1996. (Also available at:Dynamic Report.htm)
- *Estimation of Household Demand for Goods and Services in California's Dynamic Revenue Analysis Model* by Peter Berck, Peter Hess, and Bruce Smith, 1998. (Available from Economic Research, California Dept. of Finance, 916-322-2263.)

[1] For comprehensive discussions on the development of the California Dynamic Revenue Analysis Model see *Dynamic Revenue Analysis for California*, Summer, 1996, by Peter Berck, E.Golan and Bruce Smith and *Estimation of Household Demand for Goods and Services in California's Dynamic Revenue Analysis Model* by Peter Berck, Peter Hess and Bruce Smith. Both available from: mailto:bruce.smith@dof.ca.gov

2.2 General introduction to CGE models.

- The details are not repeated here, as they may be found in the publications listed above. However, several things distinguish CGEs from other kinds of economic models, including:
  - If you were to look for a single defining characteristic of a CGE, look to its objective function: to find a set of prices which clears all markets simultaneously. This means quantity supplied equal to quantity demanded in each market—for each factor, good or service.
  - Some equations describe the behavior of utility maximizing households who supply all factors of production to earn incomes to allow the purchase of goods and services, the payment of taxes, and savings.
  - Other equations describe the profit maximizing behavior of firms, that supply goods and services to earn revenues to pay for factors of production, intermediate goods, taxes and profits.
  - Some goods and services are intermediate goods that are supplied to other firms.
  - Some supply and demand arrangements are in foreign markets.
  - Governments are active agents in properly constructed CGEs. They demand real goods and services, they supply real incomes (including transfer payments), they save or dissave, and they rent factors of production[2].
  - Properly constructed CGEs are immune from the 'Lucas Critique'[3].
- There are alternative styles of models, but each has potential flaws that may preclude their use for analyzing the net revenue impact from tax law change:
  - Econometric simulation models are not immune from the Lucas Critique, but are the preferred type of model for forecasting.
  - Input-output models would be appropriate only for changes to a tiny piece of a huge economy, done once, and without warning[4].

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[2] These points are basic, but some analysts persist in making their governments 'black holes'. A case based on computational issues was valid only years ago for doing this. Thankfully the days for getting away with that are done.

[3] The following is an extremely brief summary of the Lucas Critique. Dr. Lucas observed models being estimated from past data. Then, he observed them being used as if the relationships could be exploited by policy makers. He objected. He recognized that the estimated coefficients would depend on the old policies for their size and perhaps even their sign. Therefore policies that may seem optimal may not be quite so optimal once they are implemented. CGEs would be immune from his critique, as they attempt to build in the utility and profit maximization decision processes of economic agents. For a full explanation, see: Chapter 3, *Optimal Regional Economic Policies from Computable General Eqilibrium Models,* Bruce Smith (Doctoral Dissertation).

[4] Typically, the results of input-output analysis form the extreme outer bounds of policy analysis. It is not appealing to assume that resources used for something are lying around perfectly idle in the absence of policy action. Zero is an 'unusual' assumption for an economist to make of the opportunity cost of a resource.

2.3 General introduction to DRAM.

- It is a huge model, with over a thousand constraints. It is so large that significant organizing efforts have been made. There is a single place where parameters are defined, one to make calculations on them, followed by one to define variables, one for equations and one for output. It even has a table of contents in the comments at the beginning!
- It can be classified as a neoclassical CGE with perfect competition in every sector. Readers are reminded that perfect competition includes each of the following:
  - No single agent (firms or households) who supplies or demands has any influence on the market price—be it the market for a good, service or factor.
  - Each good, service and factor is homogeneous. This means that every one is a perfect substitute for every other one, within a given market.
  - Perfect information exists. This means that there are particularly well-informed consumers, recruiters, retailers, employees, etc.
  - No barriers exist to entry or exit.
- Clearly, it is based on unrealistic assumptions. Just as obviously, most markets behave as if the conditions for perfect competition hold.
- It is such a big model that you should not hesitate to ask for help from Bruce Smith .
- A final piece of advice: give DRAM a chance. It is easy to let your eyes glaze over when you are reading the description of a model the size and complexity of DRAM. It's up to you to watch for this.

2.4 General introduction to GAMS.

The Manual:

- *GAMS A User's Guide*, Brooke, Anthony, David Kendrick, Alexander Meeraus and Ramesh Raman, 1998

How to install the software on a PC[5]:

- Identify one of the hard drives with 15 meg. free on it. I will assume it is C:, but it doesn't have to be. Below, where you see 'c:', substitute your drive letter of choice. Similarly, I have assumed your directory to be c:\gams, which I will trust you to change as necessary.
- Open a DOS partition. Put the first GAMS disk in the A: drive, then type:

md c:\gams
cd c:\gams
copy a:*.*

- Put the next GAMS disk in A: when prompted and repeat.
- When you've gone through all the gams disks, type: **gamsinst**

[5] This section describes how to install version 2.25 for DOS. Please consult the GAMS installation instructions for other versions.

- The responses to each question, but one, are up to you. When **gamsinst** asks you what solver you are using for non-linear problems, answer: **conopt** (if that is one of the solvers you bought).
- I'm going to assume that you put the GAMS library of programs in c:\gams\gamslib. Try one of the programs in the library:

cd gamslib
gams trnsprt.1

- If you get a message that your computer can't find GAMS, then add the location of GAMS to your 'path' statement. The simple way to find out what is in your path statement is to type **path** and hit return.
- Keep at it until GAMS solves the transportation problem in the model library.

I presume you were expecting a GAMS primer at this point, but you won't find it here: that is not the purpose of this document. Instead, I chose to include an explanation of some of the more obscure elements of the DRAM input file.

$OFFSYMLIST OFFSYMXREF
OPTIONS SYSOUT=OFF, SOLPRINT=OFF, LIMROW=0, LIMCOL=0;
FILE RES /DRAM00.RES/;
RES.PW = 250; RES.ND = 6; RES.LW = 13; RES.NW = 13; RES.LJ = 1; PUT RES;

- The first of these statements turns off the symbol listing and cross-reference table in the output file. The second does the same with elements of the solution by limiting the printing of 'rows' or constraints, and limits the printing of 'columns' or variable listings.
- As with other output file print controls, remember that the output file that GAMS prepares (the one with the extension 'lst') is rarely printed.
- The file we go to some pains to set up (the one with extension 'res') has all of the results we want. The third statement sets up the file and associates the buffer called 'res' with that file.
- The fourth line is actually made up of six lines of code, as follows:

RES.PW = 250;	Sets the print width to 250.
RES.ND = 6;	Sets the number of decimal places to six.
RES.LW = 13;	Sets the label width to 13.
RES.NW = 13;	Sets the number width to 13.
RES.LJ = 1;	Sets the label justify to 'left'.
PUT RES;	Sets the file buffer for 'res' to 'on'.

$INCLUDE SAM00.PRN
$INCLUDE CCM00.PRN
$INCLUDE MSC00.PRN
$INCLUDE LAB00.PRN

- These lines have the effect of inserting the contents of the four files here, as if they were included at this point. See section 3.1 of Chapter 5 of this document for further information about these files.

P.L(Z)$(ABS(P.L(Z)) LT 0.00000001) = 0;

- This line was included as an example of several elements of syntax in GAMS, including:
- The **.L** element. In GAMS, there are several parameters associated with a parameter or variable:

.L The level of a variable.
.LO The lower bound for a variable.
.UP The upper bound for a variable.
.M The marginal cost/benefit of another unit of the variable.

- The use of the dollar operator, which in GAMS is best described as the 'if' operator, when used this way.
- That is the way it is used in the line above, which can be translated as: let the level (**.L**) of each price (**P**) equal zero if the argument enclosed in the parentheses takes on the value 'true', meaning non-zero. The argument in the parentheses is true if the absolute value of the level of **P** (for the elements in set **Z**) is less than a 'very small number'.

2.5 How to analyze a bill.

Several things should be kept in mind at this point:

- DRAM is merely a tool. It does not perform bill analyses. While it can contribute to the bill analysis process, it has more potential to impede it. DRAM was designed to have its results passed through an economist doing bill analysis[6].
- Not every bill analysis can be enhanced by running experiments with DRAM. Poor candidates include:
- Bills with low static[7] estimates. We use it for bills with a static estimate $10 million or higher. Left to ourselves, the limit would be at least $100 million. When one puts $10 million in perspective:
    - It is 0.013 percent of CY General Fund ($76.9 billion for FY 2000-01).
    - It is less than one thousandth of one percent of the economy: California personal income was over one trillion dollars in 2000.
- Bills with no apparent motivation for people to change their behavior. If the authors of bills seek the dynamic analysis, they expect it to 'pay for itself' from behavior changes that generate added revenues to make up for the initial losses of tax revenues. The first thing you have to ask yourself is: how will the behavior of economic

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[6] If these statements seem to be splitting hairs, you may need more training before using DRAM. They are critical issues.

[7] By 'static estimate', I mean an estimate that ignores the reaction of economic agents to the law change. For example, a purely static esimate of a sales tax added to a good or service would take the amount now sold and multiply by the tax rate. Few fiscal analyses of bills would be this simplistic. Most would try to estimate some responsiveness (elasticity) of consumers to price changes.

agents change? If the only reasonable answer to this question is: "not much more than marginally", then you should expect little in the way of feedback effects.

- Bills with a negative feedback effect. By a negative feedback effect, I mean tax reduction in which the static estimate of revenue reduction is actually less than the dynamic estimate (in others words, the converse of the normal case). PIT reductions for high income individuals and very narrowly-applicable sales or profits tax reduction are prime candidates.

- Before you start editing and running a DRAM input file, sit back and think for a few minutes. Ask yourself the following questions:
  - How will this bill affect households?
    - Will it create an incentive for non-residents of California to relocate here?
    - Will it create an incentive for current residents to leave?
    - Will it change the rewards to work?
  - How will is this bill likely to affect business owners?
    - Will it create incentives for business people to invest in or outside California?
    - Will it tend to raise or lower prices and, by extension, profits?

2.6 How to analyze a bank & corporation tax bill.

TYPICAL RESULTS:	BROADLY -BASED	NARROWLY -BASED	UNITS
REVENUE FEEDBACK	20	0 TO 15	PERCENT OF STATIC ESTIMATE
INVESTMENT	255	0 TO 150	$ MILLION PER $1 BILLION STATIC ESTIMATE
EMPLOYMENT	8,000	0 TO 6,000	JOBS PER $1 BILLION STATIC ESTIMATE

In the table above are typical results, with the results of a billion dollar across-the-board change shown in the column under the heading 'broadly-based'. How were these results created?

- First, the model was solved for current conditions. Solving it to replicate the current economy every time it is run may seem compulsive. It probably is, but this step adds seconds to the solution time and avoids having to guess at how the change you made affected the base case. If you want to compare 'before and after', use a 'before' with familiar numbers.

- Then, the tax rates were changed, as shown below:

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* EXPERIMENT 1: BANK AND CORP TAX REDUCTION
TAUFX('CTBAC','CAPIT',I)=TAUF('CTBAC','CAPIT',I)*( Y0('CTBAC')-1)/
Y0('CTBAC');
SOLVE DRAM00 MINIMIZING SPI USING NLP;
R1('STATIC','BAC') = - 1;
```

  - The first of these lines is a comment. Note that it begins with an asterisk.

- The second reads: for each sector (the set I), the experimental factor tax rate (**TAUFX**[8]) for California bank and corporation tax (**CTBAC**) is set equal to the base case sector rate for this tax (TAUF), times the total collected in the base period minus 1 (**Y0(‘CTBAC’)-1**), all divided by the total collected in the base period (**Y0(‘CTBAC’)**).
- The third reads: solve the model[9].
- The fourth reads: set the static estimate for this experiment to minus one (billion dollars).

- The program lines immediately following, insert results into the various matrices, for later dumping into a file. When you think you are done with an experiment, bring up the file with any text editor or word processing package. Examine it.

Other experiments: put statements such as these before your ‘solve’ statement:

- Increase the Manufcturers’ Investment Credit (MIC) by one percentage point, for sectors now eligible[10]:
  ITCE(I,J)$ITCE(I,J) = ITCE(I,J) + 0.01;
  R1('STATIC','DRAM00') = SUM(I, SUM(J, N0(I) * CCM(J,I)
  / (1 + SUM(GS, TAUQX(GS,J))) * ITCE(J,I)) - ITC0(I));
- Note the use of the if operator ($) in the first line. Used this way it reads: the parameter for the investment tax credit eligibility, **ITCE(I,J)**—for this investment in sector **I** of goods of type **J**— is equal to the old level plus one percent, if the old level was non-zero.
  - Add agriculture to the list of industries eligible for the MIC[11]:

  ITCE(I,’AGRIC’) = ITCE(I,’OTHMA’);
  R1('STATIC','DRAM00') = SUM(I, SUM(J, N0(I) * CCM(J,I)
  / (1 + SUM(GS, TAUQX(GS,J))) * ITCE(J,I)) - ITC0(I));

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[8] We used a definate naming convention in DRAM. Key tax parameters are in greek, with the experiimental levels the same greek letter with the letter ‘X’ added. For example, **TAUF** and **TAUFX**.

[9] You may note that the objective is to minimize total state personal income (**SPI**). Unless the result would be the same when you maximize the same variable, or maximize or minimize any other variable, we do not have a general equilibrium problem. Try $\max_x$, then $\min_x$, subject to: $x + y = 5$ and $x + 2y = 8$. If you get something other than $x = 2$ and $y = 3$ when you maximized x and when you minimized x, do it again.

[10] Note that this is the one experiment with feedback effects significantly greater than those shown earlier. A broadly-based MIC increase is estimated to have about 30 percent revenue feedback effects. A more narrowly-based MIC changes will produce lower estimates.

[11] Note: the following is a stock wording for credits for the agricultural industry:

For a policy change to produce significant revenue feedback effects, it needs to induce employers and households to change their behavior in ways that expand revenue-producing economic activity in California. Given that the taxpayers who would benefit directly from the tax credit pay below-average taxes, it is not reasonable to expect that direct revenue feedback effects would be significant. Indirect effects from increased employment would produce below-average revenue effects given below average wages in agriculture. Overall, it is not reasonable to expect these direct and indirect effects to overcome the contractive effects of budget balancing.

- Increase the MIC by ten percent, for sectors now eligible:

ITCE(I,J) = ITCE(I,J) * 1.1;
R1('STATIC','DRAM00') = SUM(I, SUM(J, N0(I) * CCM(J,I) / (1 + SUM(GS, TAUQX(GS,J))) * ITCE(J,I)) - ITC0(I));

- Give a $100 million tax break to the electronics industry:

TAUFX('CTBAC','CAPIT','ELECT') = (TAUF('CTBAC','CAPIT','ELECT') * R0('CAPIT','ELECT') * FD0('CAPIT','ELECT')–0.1) / (TAUF('CTBAC','CAPIT','ELECT') * R0('CAPIT','ELECT') * FD0('CAPIT','ELECT'));
R1('STATIC','DRAM00') = (TAUFX('CTBAC','CAPIT','ELECT')– TAUF('CTBAC','CAPIT','ELECT')) * R0('CAPIT','ELECT') * FD0('CAPIT','ELECT');

2.7 How to analyze a sales & use tax bill.

Typical results:	Broadly-based	Narrowly-based	Units
Revenue Feedback	8	0 to 6	percent of static estimate
Investment	125	0 to 100	$ million per $1 billion static estimate
Employment	11,000	0 to 8,000	jobs per $1 billion static estimate

- As with the results for the Bank & Corp. tax above, the results in the column headed by 'broadly-based' can be used for increases or decreases in the overall tax rate. Just like for the Bank & Corp. tax, zero should be the starting point for revenue feedback estimates for a single sector-reduction in this tax, unless you can think of an overpowering reason to the contrary.
- The 'broadly-based' results were generated by the following key lines:

TAUQX('CTSAU',I) = TAUQ('CTSAU',I) * (Y0('CTSAU') - 1) / Y0('CTSAU');
R1('STATIC','DRAM00')=SUM(I,(TAUFX('CTSAU',I)–TAUF('CTSAU',I))*P0(I)* Q0(I)));

- An alternative broadly-based proposal would be to tax services:

TAUQX('CTSAU','OSERV') = TAUQ('CTSAU','ELECT');
TAUQX('CTSAU','OTHMA') = 0.95 * TAUQ('CTSAU','OTHMA');

- Another broadly-based example would be to reduce sales tax by ¼%.

TAUQX('CTSAU',I) = 0.90 * TAUQ('CTSAU',I);

  - Here, one-quarter percent is about ten percent of the total collection of sales and use tax. If it isn't, adjust the 0.90 figure.

- Sales tax exemption for bunker fuels.

TAUQX('CTSAU','PETRO') = 0.95 * TAUQ('CTSAU','PETRO');

  - This fuel is made by the PETRO sector, and (in this hypothetical example) accounts for five percent of that sector's output value.

2.8 How to analyze California personal income tax (PIT) bills.

	Income Level		
Concentration:	High	Medium*	Low
Revenue Feedback (%)	-5 to 0	3	10 to 15
Investment ($million)	30	60	90
Employment	10,000	15,000	20,000

* or more broadly-based.

Note: the investment and employment figures shown are for a bill with a static estimate of revenue gain or loss of $1 billion.

- You will notice that I have changed the presentation of the standard results. This is due to the fact that the dynamic analysis of PIT bills is more highly dependant upon the income distribution of the tax cut (or increase) than other forms of tax change.
- The key to generating feedback effects from PIT changes are migration patterns, not participation rates. That is why there is so little change to the real economy until three years, and our analysis is based on five or six years. It takes that long to get people to move between states, according to the economics literature..
- At the low end of the income scale, California PIT makes up such a small part of spending that migration can actually be net negative for tax reduction. In-migration tends to lower market wages for everyone. If PIT is sufficiently small a portion of expenditure (like zero or one percent) then after-tax incomes fall, which cuts into labor supply.
- At the other end of the income scale, so much of the tax cut flows to the federal government (through higher rates of state taxes itemized) that, even with substantial gross feedbacks, the net revenue feedback is hard pressed to turn positive. On average, with an across-the-board tax cut, 25 percent of the tax cut flows to Washington.

How to analyze various kinds of PIT bills:

- An across-the-board cut in PIT rates to save Californians $1 billion.

TAXCVCX('CTPIT',H)=TAXCVC('CTPIT',H)*(Y0('CTPIT')-1)/Y0('CTPIT');
R1('STATIC','PIT') = - 1;

- A $100 tax credit for low income Californians .

TAXCRED('CTPIT','HOUSO') = 0.100;
TAXCRED('CTPIT','HOUS1') = 0.100;
TAXCRED('CTPIT','HOUS2') = 0.100;
R1('STATIC','PIT') = - SUM(H, TAXCRED('CTPIT',H) * HW0(H));

- A 'pure flat tax' system.

MTR(H) = PIT0('CTPIT') / SUM(H1, AGI(H1));
TAXBASE('CTPIT',H) = 0;
TAXBM('CTPIT',H) = 0;
TAXSD('CTPIT',H) = 0;
TAXOD('CTPIT',H) = 0;
TAXPI('CTPIT',H) = 0;
TAXCVC('CTPIT',H) = 1;
R1('STATIC','DRAM00') = SUM(H, (TAXBASE(GI,H) + (AGI0(H) - TAXBM(GI,H) – TAXSD(GI,H) - (TAXOD(GI,H) + SUM(GI1, ATAX(GI1,GI) * PIT0(GI1,H))) * TAXPI(GI,H)) * MTR(GI,H)) * TAXCVCX(GI,H) - TAXCRED(GI,H)) - PIT0('CTPIT');

    - By 'pure flat tax' system, we mean no deductions of any kind. It is extremely unlikely that you will ever encounter a proposal of this kind, so be sensitive to the details of how the proposed legislation you are analyzing differs from a ‘pure flat tax’.

2.9 How to analyze other types of California tax bills.

We cannot expect to anticipate the efforts of 40 State Senators and 80 members of the Assembly, their staffs, industry associations and lobbyists in coming up with legislative ideas. However, the following were culled from the first few years of actual dynamic revenue analysis:

- Halve the excise tax on gasoline:

TAUQX(‘CTGAS’,’PETRO’) = TAUQ(‘CTGAS’,’PETRO’) / 2;
R1(‘STATIC’,’DRAM00’) = (TAUQX(‘CTGAS’,’PETRO’) - TAUQ(‘CTGAS’,’PETRO’)) * P0(‘PETRO’) * Q0(‘PETRO’);

  - You may note that we have chosen to model this as a cut in the tax on all petroleum products (with the exception of the tax on diesel fuel, CTDIE) and that these are modeled as percentage taxes, rather than as per gallon. These are examples of simplifying assumptions.
  - First, excise taxes on gasoline make up the lion’s share of CTGAS. The only other major component is the excise tax on airplane fuel. While patently wrong, it is near enough to being right to consider the tax as uniform.
  - The second simplifying assumption arises from the fact that liquid petroleum products have the only tax imposed on a per unit basis, other than the per package tax on cigarettes. Both are modeled as percentage of selling price to simplify the model.
  - Since the tax on gasoline itself is subject to sales and use tax, the feedback effects of this can be surprising.

- Cut the vehicle license fee by ten percent.

TAUQX(‘CTLIC’,’MOTOR’) = TAUQ(‘CTLIC’,’MOTOR’) * 0.90;
R1(‘STATIC’,’DRAM00’) = (TAUQX(‘CTLIC’,’MOTOR’) - TAUQ(‘CTLIC’,’MOTOR’)) * P0(‘MOTOR’) * Q0(‘MOTOR’);

- Increase the tobacco tax by 50 percent.

TAUQX(‘CTCIG’,’TOBAC’) = TAUQ(‘CTCIG’,’TOBAC’) * 1.5;
R1(‘STATIC’,’DRAM00’) = (TAUQX(‘CTCIG’,’TOBAC’) - TAUQ(‘CTCIG’,’TOBAC’))* P0(‘TOBAC’) * Q0(‘TOBAC’);

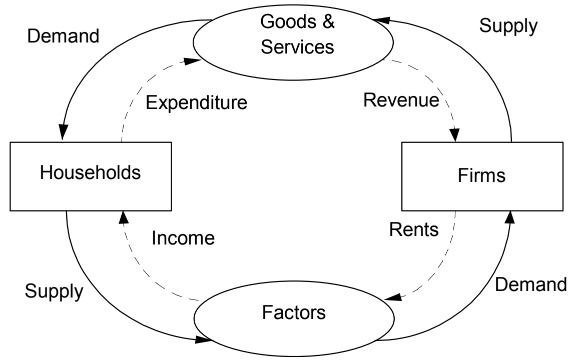
3 Model Description

Finally, we describe the DRAM, after several pages allocated to describing how to use it. Before you reject this ordering, remember the purpose of this document: it was prepared to broaden the accessibility of this model for researchers inside and outside the DOF.

The California dynamic revenue analysis model (DRAM) consists of about 1300 equations describing the behavior of consumers, producers, and government. These agents trade goods and services with the rest of the world—for DRAM defined as all agents and markets outside California.

The agents utilize factors of production grouped as capital (buildings, equipment, inventory, land and entrepreneurial effort) and labor. The four kinds of economic agents (firms, households, government, and foreign) provide the framework for explaining the model. The discussion will provide some sense of the general issues involved in state-level CGE modeling, especially as these issues differ from the issues involved with national models. Figure 1 presents a simplified view of the basic economy and gives a reference point for the discussion following.

Figure 1: The Basic Circular Flow Diagram



Firms supply goods and services and **demand** factors of production. For the purposes of DRAM, California is treated as an economy with 28 goods and services operating in perfectly competitive markets, and two factors, capital and labor. The sole objective of each firm is **profit maximization**. Thus, while there is one arrow in the diagram above for the demand for factors, there are 56 (2 factors times 28 industries) equations and variables in the model. Similarly, for the nominal or money flow (the dotted lines), there are 56 equations and variables describing factor payments.

To maximize profits, firms respond to changes in the price of and demand for their product and the cost of their inputs (capital, labor, and intermediate goods), including taxes. In Figure 2, the markets for other inputs (intermediates) have been added, along with trade flows and government. Intermediate goods are supplied by firms to other firms, rather than as final demand by consumers.

Households in a CGE model **demand** goods and services, and **supply** factors of production. Households **maximize utility** (happiness) from consuming goods and services from income gained by **supplying factors of production**. California households are aggregated into eight groups, each corresponding to a California Personal Income Tax marginal rate (0, 1, 2, 4, 6, 8 and 9.3 percent), with the last group subdivided into over and under $200,000 adjusted gross income.

Each household maximizes utility subject to an after-tax, non-saved income constraint and relative prices of goods and services. Prices are inclusive of sales and excise taxes, and incomes net of wealth taxes (property, estate) and income taxes (state and federal). To the extent practical, fees (state and local) were allocated to corresponding consumption goods. Incomes are derived from renting (*i.e.* receiving payment for) factors of production (capital and labor).

A desired **capital stock** for each industry is established in response to the after-tax return to capital in each sector. The difference between desired and actual capital stock drives investment demand.

Labor supply decisions of households take two forms; changes in the participation rates of various household types and changes in the labor force due to migration. Changes in participation rates are small in relation to the effects of migration decisions, as has been found in many empirical studies of the issue. Interstate migration decisions make up the major source of the labor market responses to tax rates in properly designed economic models of states. Some researchers have found that personal income taxes of states are a major determinant of relative wages between states, through the mechanism of encouraging and discouraging interstate migration. In national models, interstate migration is ignored, as are the effects of national tax rates on international migration. This is a major difference between national and state analysis of the economic effects of tax policy changes.

Savings identify another important distinction between an economic model of a state and that of a nation. It is widely accepted in national modeling to incorporate a strong relationship between savings and investment. Thus, the motivation to save in a national CGE becomes one of the primary functions that define results. Investment resulting from tax policy changes frequently delivers the economic expansion or contraction that underlies the policy analysis results.

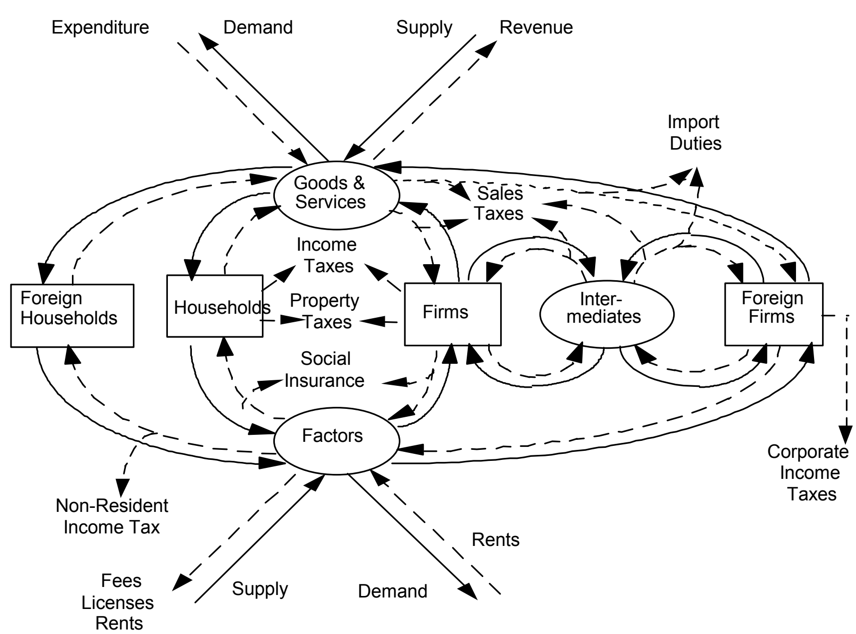
Regions exhibit the same relationship between savings and investment, but it is dwarfed by inter-regional and international capital flows. Information costs increase outside the region and these, in theory, can be the source of interest rate differences, but this is rarely observed. Savings in California join national and international financial capital pools so large that rates of return depend very little on changes in California savings.

In a state-level CGE, savings becomes a drag on private market activity with no explicit effect on local investment. The result is that the efforts exerted in building the savings motivation in national CGE models were not repeated in the California model. Savings are fixed shares of after-tax household income, with these rising with income.

Foreign markets matter more in a regional than in a national model. In a state-level CGE, foreign markets are those of other countries and of the other 49 states. Regional economies trade a larger share of their output and are more open to trade than are national economies, since interstate trade is added to international trade for regions. In DRAM, demand and supply for the rest of the U.S. is added to the rest of the world, and represented in one equation for export demand and one equation for import supply for each of the 28 groupings of goods and services. In each of these 56 equations, trade quantities depend on relative prices.

Government acts as a demander of factors of production and of goods and services, while obtaining its revenues by taxing factor payments (corporate and individual income taxes), consumption (sales and excise taxes) and wealth (motor vehicle license fees, estate taxes and property taxation). Further, much like households face a budget constraint, California faces a balanced-budget requirement.

Figure 2: The Circular Flow with Intermediate Goods, Trade and Government



Stock market and mutual fund purchases are clearly multi-state and multi-national. But even deposits in local banks or savings institutions are swept up in the worldwide capital markets. Large banks almost always use excess household deposits to fund national, corporate and multi-national lending. Smaller banks are significant net providers of Federal funds and a major source of funding for wholesale business lenders.

Money and credit markets are highly intolerant of bond-financed deficits and their responses make it realistic to model the government sector in California by having tax reductions matched with expenditure reductions. This feature of DRAM was singled-out as being highly realistic by external reviewers of the model.

4 Sensitivity Analysis Experiments

The model was exposed to a series of sensitivity analysis experiments in its original form and for each of the two subsequent updates. Full details of these are available. The model has been used since January 1997 as the key analytical engine behind dynamic revenue analysis of all formal legislative proposals with a static estimate of $10 million or more, approximately 400 unique bills not counting amendments.

To demonstrate the model's workings, policy experiments are presented. These repeat the base case results of the sensitivity analysis experiments and do not reflect any known pending legislative action. The model was solved three times.

1. An across-the-board reduction in corporate profits taxes (the bank and corporation tax) that would produce a static estimate of $1 billion. This is approximately an 18 percent reduction in revenues for this tax, equivalent to reducing the corporate rate from 8.835 percent of profits to approximately 7.333 percent.
2. An across-the-board reduction in personal income tax rates that would produce a static estimate of $1 billion. This is approximately 4 percent of personal income tax revenues, equivalent to reducing the top marginal rate from 9.3 percent to approximately 8.9 percent, with proportionate changes down the marginal tax schedule.
3. An across-the-board reduction in sales and use taxes that would produce a static estimate of $1 billion for California, approximately a 12 percent revenue reduction for this tax source. As local governments apply sales and use taxes on top of California taxes and as California has committed a significant portion of its sales and use tax revenues to local governments, the composition of this last experiment is unlike that of the other two tax reduction experiments in terms of its general *versus* special fund allocations (the first two are virtually completely general fund revenues).

The results of the base case experiments are shown in the table below, and are indicative of the output generated in typical model experiments. In selected cases for individual revenue bills and when reformulating the model, the output table can be expanded dramatically. Table 1 displays a tiny subset of the 1,300 variables. However, in presenting results to elected officials, three numbers have been of most interest; percentage revenue feedback effect, employment changes and investment changes. These results reflect changes in the economy five or six years after implementation of tax policy changes, assuming that the California budget is kept in balance, and independent of any other structural change in the economy.

Table 1: Base Case Dynamic Revenue Analysis Results	Bank & Corp. Tax	Personal Income Tax	Sales and Use Tax
Revenue Feedback, % of static estimate	20	3	8
Employment, thousands of jobs	8	15	11
Investment, millions of dollars	255	60	125

Solution 1: Bank and corporation tax rate reduction leads to about 20 percent of the static estimate of revenue loss flowing back to the California government in all forms of taxes, about eight thousand new jobs, and over one-quater billion dollars in new investment. That 20 percent of the static estimate of revenue loss flows back, 80 percent does not. However, it is important to note that private economic growth exceeds the contracting effects of government spending reductions to create eight thousand net new jobs and significant new investment. California taxation of business profits matters to the private economy.

While all equations are solved simultaneously, it may be informative to trace the major effects through the economy as if they were sequential.

- Households find that they keep a larger share of non-labor payments and increase their supply of non-labor factors of production (called 'capital' in the model), thus creating downward pressure on the pre-tax return.
- Firms face lower relative prices for capital and substitute towards capital in production. However, they encounter increasing profit margins that are squeezed out in the form of lower domestic prices.
- Their shares of domestic and foreign markets increase, increasing the demand for domestic goods which leads to increased production to the point where demand for both labor and capital increase.
- Household incomes rise (through increased demand for labor and higher after-tax capital payments) and consumption drives up domestic demand.
- However, the government cuts back its expenditures to balance the budget, reversing some of these effects.
- Equilibrium is found with the private economy growing sufficiently to more than compensate for the reduction in government expenditure in terms of jobs, output and investment.

Solution 2: Personal income tax rate reduction leads to about three percent of the static estimate of revenue loss flowing back to the California government in all forms of taxes, about 15 thousand new jobs, and about 60 million dollars in new investment. That three percent of the static estimate of revenue loss flows back, 97 percent does not. This does not imply that personal income tax reduction is a poor strategy, only that each dollar of static estimate is a very close approximation to the long run dynamic estimate. These results are different from profits tax reduction and from the results of national studies, revealing fundamental differences between regional policy models and national counterparts.

The starting points for personal income tax reduction differ from those for profits taxes:

- Households increase their willingness to work in response to the after-tax return to work. However, the migration effects would dwarf these effects. At the margin, some households facing tax reduction find California a better place to live and work, increasing net in-migration.
- Equilibrium wages fall slightly, leading employers to hire more and follow a path parallel to that of reduced taxes on capital in economic consequences (output levels, prices and trade consequences).
- A key difference is found in the highly progressive nature of income taxes in California. Lower income households (those in the 0, 1 and 2 percent brackets) face a reduction in average wages that reduces their after-tax wage (*i.e.* wage reduction exceeds tax reduction), with the model suggesting net out-migration for these groups that partially offsets in-migration in middle and upper income groups.
- In national models, the feedback effects from reduced personal income tax generate larger revenue feedback effects. The absence of international migration functions is at the heart of the difference. With appropriately modest labor supply responses, results derive primarily from demand-side effects of increased after-tax incomes leading to increased demand. Thus, without significant drops in wage rates (from labor force growth), revenue feedback effects are higher in well-designed national models.

Solution 3: Sales and Use Tax Rate Reduction leads to revenue feedback results between those of profits taxes and income taxes. However, the effects are more like the more modest numbers of each—similar to profits taxes for jobs and income taxes for investment. Based on more focused experiments, it was discovered that most of the feedback effects derive from reducing sales taxes on intermediate goods. California is one of very few states to do so and these taxes become a drain on the bottom line of firms. Their removal reduces the cost of doing business in California, leading to better import and export performance and economic expansion.

5 Guide to the Input File(s)

In DRAM, the algebraic representation of the relationships between the agents in the California economy is implemented using the General Algebraic Modeling System (GAMS). The GAMS program breaks the model into sets, variables, parameters, equations, and an artificial objective function. The following is a very brief description of the five files by which we implement the model in the form that GAMS can give us our results. The description is centered on the main file, called **DRAM00** in the version we have used (note the lack of extension to this file name).

5.1.1 Before Section 1.0:

- The **$TITLE** command causes the title "DYNAMIC REVENUE ANALYSIS MODEL" to be printed in the LST output file. The LST file contains an echo print of DRAM plus program diagnostics useful for debugging.

- The **$ONTEXT** followed by **$OFFTEXT** (p. 113[12]) allows the creation of block comments in the program contained between the two commands. Any lines between **$ONTEXT** and **$OFFTEXT** are ignored by GAMS during program execution.
- The lines between the commands represent a table of contents that are entirely superfluous, but have proven highly useful.

5.1.2 Section 1.1:

- Sets up controls for output generation.
- The **$OFFSMYLIST OFFSYMXREF** command tells GAMS not to produce maps in the LST file (p 113).
- The **OPTIONS** command, currently commented out by the asterisk, controls output following a solve statement (p. 103).
- Note that output is controlled to the file that GAMS creates (with the extension "LST"), even though this is not the file that is usually printed (the "RES" file). This is due to buffer size limitations when using text editors such as found in DOS.

5.1.3 Section 1.2:

- **FILE RES /DRAM00.RES/;** (p. 275) command tells GAMS to create a disk file named **DRAM00.RES** from the logical file RES. Note that the logical file containing the results (RES) is created by this command, but stays a virtual file until written to disk.
- The specifications after the **FILE RES** command set output specifications (p. 286). For example, **RES.PW** sets the print width or the maximum number of characters on a single line.
- The **PUT RES** command tells GAMS to write the output results to the disk file (p. 275).

5.1.4 Section 2.1

- This block of commands declares sets and lists the elements of the sets.
- In GAMS terminology: indices are called sets, data are called parameters, decision variables are called variables, and constraints and the objective function are called equations.
- A declaration of the sets used in DRAM is included in section 2.1 and is invoked by the **SETS** command (pp. 12, 43-50).
- A new set that is a subset of a declared set can be declared with mapping defined on the larger set and a list of elements to be included in the new set. For example: **C(Z) /CFOOD, CHOME, CFUEL, CFURN, CCLTH, CTRNS, CMEDS, CAMUS, COTHR/;** declares 'c' to be a subset of 'z', a subset with various explicit members.

[12] Page numbers are from *GAMS A User's Guide*, Release 2.25, by Anthony Brooke, David Kendrich and and Alexander Meeraus.

- Note that the list of elements in the subset must all be contained in the larger set, but need not be a proper subset (*i.e.* it can be null, or contain all of the elements of the original set).

5.1.5 Section 2.2:

- The GAMS concept of an **ALIAS** is really quite simple. If something has been declared to be an alias of a set, it can be used even within the same statement as representing the same list of things, but a different copy of that list.
- For instance, a parameter **A(Z,Z1)** can be an industry input-output (I/O) matrix where **Z** and **Z1** represent the same set of social accounts.
- To illustrate why this is important, consider the expressions **A(Z,Z)** and **A(Z,Z1)**. The set of parameters produced by **A(Z,Z)** is limited to the elements of the principal diagonal of **A(Z,Z1)**. **A(Z,Z1)** is all the elements of **A(Z,Z)** plus those elements where **Z≠Z1**, i.e. the full matrix.

5.1.6 Section 3.1

- In this section, we read in external data sets. These are in external files only for the convenience of analysts. We stress that they do not have to be in separate files.
- These have been placed in four files. GAMS interprets the **$INCLUDE SAM00.PRN** command to insert the lines of the file **SAM9899.PRN** right where the program finds the **$INCLUDE SAM00.PRN** statement. The four files are:
  - **SAM00.PRN**: the social accounting matrix, a representative element of which is **SAM(I,J)**—the payment (in billions of dollars) from sector **J** to sector **I**. For example, **SAM('FOODS','AGRIC') = 2.472692**. This means that the agriculture industry bought about two and one-half billion dollars worth of the output of the food industry as an input to the agriculture industry.
  - **CCM00.PRN**: the capital coefficient matrix, a representative element of which is **CCM(I,J)**—the share of a dollar invested by industry J that is spent on the output of industry I. For example, **CCM('ENMIN','CONST') = 0.139782**. This means that the energy mining industry spends about 14 percent of each investment dollar on construction.
  - **MSC00.PRN**: miscellaneous tax, elasticity and other parameters—too numerous to list here. Please look at this file, you'll get the idea.
  - **LAB00.PRN**: the initial distribution of labor by type across sectors and households [**ALPHAL(Z,L)**] and the initial wage rates [**W0(L)**].

5.1.7 Section 3.2

- Declares the parameter names. This tells GAMS which parameters will be used and assigned values later in the program.
- Note: If you know something is a parameter, but can't find it here, look in the four data files. If you can't find it there, it isn't a parameter.

5.1.8 Section 3.3

- We perform calculations on parameters. Parameters can be of several types in this section:

- Some, such as demand elasticities, remain fixed for all models.
- Others are initial values for endogenous variables. We took some care to identify this last group to other modelers. All the names are the same as their variable names, with zero added. For example, **DD(I)** has its initial values stored in **DD0(I)**.
- Some parameters are assigned values based on data read into GAMS by the **$INCLUDE** command in section 2.2. Other parameters are either assigned a value in the DRAM program or are a transformation of data read in by the **$INCLUDE** command.
- Some coding is used in section 3.3 requires explanation.

IGTD(G,G1)$(NOT SAM(G,G1)) = 0;

- This assigns the value zero to all elements of **IGTD(G,G1)** which have a corresponding 0 in **SAM(G,G1)**. This deserves some explanation.
    - First, the logic of **NOT SAM(G,G1)** is that if **SAM(G,G1) = 0**, then the statement **NOT SAM(G,G1)** is true and assigned a value equal to 1. The dollar sign ($) tells GAMS to set **IGTD(G,G1) = 0**.
    - On the other hand, if **SAM(G,G1) ≠ 0**, then **NOT SAM(G,G1)** is false and equal to 0. GAMS then leaves the value of **IGTD(G,G1)** at the value determined by the previous coding.
    - Note that it is the fact that the dollar sign is on the left hand side of the "=" that causes the value to be unchanged in the event **NOT SAM(G,G1)** is false. See pages 72-75 of the GAMS manual for further elaboration of the use of the dollar operator and exception handling.

Q0(Z) = SUM(Z1, SAM(Z,Z1));

- This tells GAMS to set $Q_z^0 = \sum_{z \in Z_1} SAM_{z,z1}$ for all $z \in Z$.
- In English, this command sets **Q0** equal to the row total in the SAM for sector **z** (see pp. 67-68 for more on the SUM operator).

5.1.9 Section 4.1

- Declares the variable names that will be used.
- We can't resist bragging about our style of modeling: it just isn't a variable if you can't find it here.

5.1.10 Section 4.2

- Assigns initial values. These were calculated in 3.3 above or input, some from other files using the **$INCLUDE** command.
- The suffix **.L** was attached to the variable name. The **.L** stands for the level of the variable. Other variable suffixes include **.M** for marginal, **.LO** for lower bound and **.UP** for upper bound (see p.120).

5.1.11 Section 4.3

- Sets variables with trace values to zero for computational purposes, by use of the **$IF** function.
- In section 4.3, the ABS function is used and produces the absolute value of the variable. For example, **P.L(Z)$(ABS(P.L(Z)) LT 0.00000001 = 0;** tells GAMS to assign the value 0 to **P.L(z)** if the absolute value of the level of **P(Z) < 0.00000001**, which means it is <u>very</u> close to zero.

5.1.12 Section 4.4

- Puts bounds on the values of the variables to assist the solver in computing the solution.
- Lower bounds are set by taking a variable (say **CS(C,H)**) and setting its lower bound equal to a specific value, say, three orders of magnitude less. In our model, we accomplish this with the command **CS(C,H).LO = CS0(C,H)/1000**.
- Upper bounds are set similarly using the **.UP** suffix and using **CS(C,H).UP = CS0(C,H)*1000**.

5.1.13 Section 5.1

- This coding causes GAMS to display, in the LST file, the initial values of several parameters.
- Note this command is currently commented out. It was last used during calibration last year.

5.1.14 Section 5.2

- The arrays **R1**, **R2** and **R3**, which were declared in section 3.2, contain the solution values for various endogenous variables of interest. Any variables can be included in these arrays, the only constraints being dimensioning, time and printing time.
- The initial values contain the index **T = 'BASE'**, meaning set equal to initial data. These values of the variables in the arrays **R1**, **R2**, and **R3** will be printed in section 7 next to the solution values of these variables for the equilibria solved for the current policy environment and those of the policy environments under examination.
- The solution for the current equilibrium will have **T = 'TODAY'.** Thus, we compare **R1(R1H, 'BASE')** to **R1(R1H, 'TODAY')** etc. and verify the values are the same. This step allows the user to verify that the model is producing solution values for the current policy environment equal to the actual values those variables have today. In essence we make sure the model takes the current policy environment and produces the current economy.

5.1.15 Section 6.1

- This section declares all equations. The command **EQUATIONS** tells GAMS to expect a list of equation names (names ≤ 8 characters).
- GAMS does not require the equation name to end with EQ. However, by ending equation names in EQ, we identify equations as such.

- Each name may be followed on the same line by descriptive text up to eighty characters. Thus the line that starts with **CPIEQ(H)** says a set of CPI equations will be defined (one for each $h \in H$).

5.1.16 Section 6.2

- This section defines each equation explicitly, though most are grouped and defined by index.
- Section 9 of the equations is made up of housekeeping entries. These may appear superfluous to the inexperienced user. They are not, as you can tell by taking any of them, putting an asterisk in column 1 and running the program. You'll get the idea.

5.1.17 Section 7.1

- **MODEL DRAM00 /ALL/** tells GAMS to use all equations in the model, which will be called '**DRAM00**'.

5.1.18 Section 7.2

- **SOLVE DRAM00 MINIMIZING SPI USING NLP;** tells GAMS to solve the model **DRAM00** by minimizing the objection function **SPI** (state personal income) using nonlinear programming (NLP). Note that any variable could have been chosen, and either direction (max or min) could have been chosen—if and only if DRAM is a 'square' system (equal numbers of <u>independent</u> equations and free variables).
- Note that our default solver setting for NLP is CONOPT.
- We save the model and solver status under **R2('M-STAT',T)** and **R2('S-STAT', T)**.
- The results of this first solution should replicate the current economy. The solution values of selected variables are 'tucked aside' in **R1, R2** and **R3**. Any other variables can be chosen by editing one of the sets (**R1, R2** or **R3**), section 4.3, and here.
- After calibrating by replicating the current economy, various experiments are conducted. Note how the last subscript in **R1, R2** and **R3** keeps changing.
- Note that **TAXCVC('CTPIT',H)** is a correction factor, which converts calculated taxes to observed tax collections. For low-income households calculated taxes are greater than observed tax receipts. For high-income households calculated taxes are less than observed tax collections. These results could be caused by lack of compliance with tax laws, earned income tax credits, alternative minimum tax collections or that one tax table (joint filing together) was used.

5.1.19 Section 7.3

- The first 'PUT' group writes headings in the buffer:
  - The line PUT '**DRAM00   ;**' tells GAMS to write DRAM00 plus the blank spaces in the first line of the output file, but to stay on this line, for now.
  - The line **LOOP(T, PUT (T.TL));** tells GAMS to write each title of the set T on the first line immediately after the spaces created in the previous line of code. Note that the suffix TL designates the title, which is in parentheses beside the element name in the set declaration.

- The third line **PUT/;** tells GAMS to output a carriage return. In other words, the next item written to the output file will occur at the beginning of the next line.

- The next '**PUT**' group creates a line for the model status of each solve.
  - **PUT 'MODEL ';** prints the word MODEL starting in the first column of the second line of output as well as several blank spaces.
  - **LOOP(T$(ORD(T) GT 1)** works through the various models (such as **BASE, TODAY, XBAC)** checking if the current model is one of the solved DRAM runs (meaning **TODAY** and **XBAC** in this example).
  - **ORD(T)** creates a number for the elements of the set **T**. The number 1 is assigned to the first element listed in the set during the set definition, and so on. Since the first element is **'BASE'**, this is assigned the number 1. Consequently **ORD('BASE') =1** is not greater than 1; therefore, the **LOOP** skips to the next element of **T**.
  - **ORD('TODAY') = 2** which is greater than one. Hence, the next **LOOP** statement is activated.
  - This statement loops through the set **MS**, comparing the value of **R2('M-STAT',T)** to the number **ORD(MS)**—the 'order' of the element in MS. Note that **R2('M-STAT',T)** was established by GAMS when it solved the model and the set MS was established when the set was first declared. If you look at the set MS you will see that it covers all of the possible outcomes for model status.
  - IF **R2('M-STAT',T) = ORD(MS)**, the **LOOP** logic is satisfied and the subsequent **PUT** statement is activated so that the label for the value of MS satisfying the equation is printed on second line after the blank spaces created by the first put statement.
- The next **PUT**/**LOOP** group is the same as for model status except it prints the solver status of each experiment.
- The last two **PUT**/**LOOP** groups output line titles and solution values for variables of interest.

6 Model Data

6.1 Elasticities and other Key Parameters

ETAED(H) = MISCH(H,'ETAED');

ETAED(H) is the sensitivity of migration to public education spending.

MISCH(H,'ETAED') is a matrix in the MSC9900 data set.

KAPPA(GNS) = 1;

KAPPA(GNS) are policy weights of government spending on infrastructure scale variable. Equal weights are given to all elements of KAPPA, an unrealistic assumption, but appropriate given the relative unimportance of this part of the model.

TAXCRED(GI,H) = 0;

TAXCRED(GI,H) is the tax credit for experiments. This allows a different tax credit to be established for each household type. Hence, it would be possible to phase out a tax credit for higher income tax payers.

ETAI(I) = 1.25;

ETAI(I) is investment supply elasticity, though one is immediately reset (see following section).

ETAI('TOBAC') = 0;

Sets investment supply elasticity to 0 for tobacco, *i.e.* do not allow a California based supply response. Not much tobacco is grown in the state nor much processed.

ETAGS(I) = 0.01;

ETAGS(I) is the production elasticity with respect to infrastructure. It measures the response of private production to public infrastructure spending. A ten-percent increase in public infrastructure spending increases private productivity by 0.1 percent.

ETAE(I)$(ORD(I) LT 16) = - 3.0;
ETAM(I)$(ORD(I) LT 16) = 3.0;
ETAE(I)$(ORD(I) GT 15) = - 0.5;
ETAM(I)$(ORD(I) GT 15) = 0.5;

ETAE(I) is the export elasticity for industry sector I with respect to the ratio of the domestic price to the world price.

ETAM(I) is the import elasticity for industry sector I with respect to the ratio of the domestic price to the world price.

They are set to levels that are responsive for goods, and more moderate levels for services. Our review of the literature did not reveal anything more precise that could be trusted.

SIGMA(I) = MISC(I,'SIGMA');

SIGMA(I) is the elasticity of factor substitution in industry sector I.

R0('CAPIT',I) = MISC(I,'R0') * 100;

RO(‘CAPIT’, I) is the initial pretax rate of return on capital for sector I.

ETARA(H) = MISCH(H,'ETARA');

ETARA(H) is the labor supply elasticity with respect to average wages.

ETAPIT(H) = MISCH(H,'ETAPIT');

ETAPIT(H) is the labor supply elasticity with respect to California personal income taxes.

ETATP(H) = MISCH(H,'ETATP');

ETATP(H) is the labor supply elasticity with respect to transfer payments.

ETAYD(H) = MISCH(H,'ETAYD');

ETAYD(H) is the responsiveness of immigration to after-tax disposable income.

NRPG(H) = MISCH(H,'NRPG');

NRPG(H) is the natural rate of population growth.

ETAU(H) = MISCH(H,'ETAU');

ETAU(H) is the responsive of immigration to unemployment.

TAXBASE(G,H) = MISCG(G,H,'TAXBASE');

TAXBASE(G,H) is the basic tax payment to government sector G for household type H. It came from the tax table.

TAXBM(G,H) = MISCG(G,H,'TAXBM');

TAXBM(G,H) is the minimum taxable income to be in bracket H.

TAXSD(G,H) = MISCG(G,H,'TAXSD');

TAXSD(GI,H) is the average for this tax bracket of standard deductions taken. The total of standard deductions was divided by total returns filed, not those with standard deductions.

TAXOD(G,H) = MISCG(G,H,'TAXOD');

TAXOD(G,H) is other tax deductions per return for household type H.

TAXPI(G,H) = MISCG(G,H,'TAXPI');

TAXPI(G,H) is the percentage of taxpayers in bracket H that itemize.

TAXCVC(G,H) = MISCG(G,H,'TAXCVC');

TAXCVC(G,H) is the correction factor that forces taxes liabilities calculated in DRAM to equal observed taxes.

TAXCVCX(G,H) = TAXCVC(G,H);

TAXCVCX(G,H) is an experimental tax correction factor.

MTR(G,H) = MISCG(G,H,'MTR');

MTR(G,H) is the marginal tax rate for type H taxpayers.

6.2 Sales, Excise and Factor Tax Rates Calculated from the SAM

TAUQ(GS,I) = SAM(GS,I)/(SUM(J,SAM(I,J)) + SUM(C,SAM(I,C)) + SUM(G,SAM(I,G))+ SAM(I,’INVES’) – SUM(GS1,SAM(GS1,I)));

The sales tax rate for sector I is equal to the ratio of tax collected on industry I goods divided by total sales of good I.

TAUQ(GS,I) is the sales or excise tax rate paid for purchases of industry sector I goods.

SAM(GS,I) is the sales tax imposed on sales of sector I goods or services.

SUM((J,SAM(I,J)) is the total intermediate goods sales in sector I.

SUM(C,SAM(I,C)) is the total consumption of sector I goods included in composite commodities.

SAM(I,’INVES’) is the value of sector I goods purchased for capital investment

SUM(GS1,SAM(GS1,I) is the total of sales taxes that must be removed from the denominator to get the actual expenditure on sector I commodities net of sales taxes.

TAUQX (GS,I) = TAUQ(GS,I)

This is the experimental sales tax rate. In the base solve the experimental rate is set equal to the current sales tax rate.

TAUM(‘FTDUT’,I) = SAM(‘FTDUT’,I)/(SAM(‘ROW’,I) – SAM(‘FTDUT’, I));

Federal duty rate on imported industry I goods is equal to federal duty collection on sector I goods divided by total imports of sector I goods.

TAUM(‘FTDUT’,I) is the duty rate for imports by sector I.

SAM(‘FTDUT’,I) is the federal duty paid on imports by sector I.

SAM(‘ROW’,I) is the total value of sector I type goods.

TAUF(GF,F,I)$(SAM(F,I) AND TAUFF(GF,F))=SAM(GF,I)/SAM(F,I)

The factor tax rate for industry I, paid for use of factor F, is equal to factor tax GF paid by industry I divided by the payments to factor F used in industry I.

TAUF(GF,F,I) are the factor taxes for factor F paid by sector I.

SAM(F,I) are the payments to factor F used in sector I.

TAUFF(GF,F) is equal to 1 if factor there is a factor tax GF for F and 0 otherwise. This is obtained from MISC. Note GF is a subset of G.[13]

SAM(GF,I) are factor taxes paid to government GF by industry I.

SAM(F,I) are the payments to factor F by industry I.

TAUF(GF,F,G)$(SAM(F,G) AND TAUFF(GF,F)) = SAM(GF,G)/SAM(F,G)

The factor tax-rate for government sector G paid for use of factor F is equal to factor tax GF paid by government G divided by the payments to factor F used in government sector G. This follows the same pattern as for the private sector (above).

TAUFX(GF,F,Z) = TAUF(GF,F,Z)

This is the experimental factor tax rate that is set equal to the current factor tax for the base solve. It will be set to experimental values, if apropriate in the analysis of particular bills.

TAUFH('FTSOC','LABOR') = SAM('FTSOC','LABOR') / Q0('LABOR')

Employee share of social security taxes xxx is equal to the factor tax GF paid by ‘LABOR’ divided by total payments to ‘LABOR’.

TAUFH(GF,F) is the employee share of factor tax GF (nonzero only for social security).

TAUFF(GF,F) is equal to 1 if there is a factor tax GF for F and 0 otherwise (obtained from MISCH file). Note GF is a subset of G.

SAM(‘FTSOC’, ‘LABOR’) are payments by ‘LABOR’ to social security.

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[13] Note that a programming ‘trick’ is embodied in this use of a subset combined with a matrix. TAUFF(GF,F) is in MSC9900. It is repeated below. Readers are reminded of the if function ($) in GAMS. Non-zero is interpreted as ‘true’, zero is ‘false’.

TABLE TAUFF(G,F) ASSIGNMENT OF FACTOR TAXES

	LABOR	CAPIT
FTSOC	1	0
FTPRO	0	1
CTBAC	0	1
CTLAB	1	0;

Q0('LABOR') are total payments to 'LABOR'.

6.3 Distributional Shares for Endogenous Intergovernmental Transfers

TAXS(G,GT)$(SUM(G1,SAM(G1,GT)) - SUM(GF,SAM(GF,GT))) = SAM(G,GT) / (SUM(G1, SAM(G1,GT)) – SUM(GF,SAM(GF,GT)))

This defines the share of a tax allocated to a government sector. Note that all GF forms a subset of all G1; therefore, the sum of all TAXS(G,GT) over G is not equal to one 1; however, in subsequent sections we avoid using TAXS(G,GT) for G not equal to any GF. As a consequence, TAXS(G,GT) does sum to 1 when summing over this restricted subset of G.

TAX(G,GT) are tax distribution shares by destination

SUM(G1,SAM(G1,GT)) is amount of tax GT transferred to all government units

SUM(GF,SAM(GF,GT)) is amount of tax GT paid in factor taxes GF.

SAM(G,GT) is amount of tax GT transferred to government unit G

6.4 Initial Inter-Governmental Transfers

IGTO(G,G1) = SAM(G,G1)

This defines initial government transfers by payments from government sector G1 to government sector G as equal to what was found in the social accounting matrix.

IGT0(GF,G) = 0

Here we set intergovernmental transfers from government units to factor tax units equal to 0. The only relevant factor tax paid by government is FTSOC, which we don't want to record as an intergovernmental transfer.

6.5 Initial Prices

PW0 (I) = 1 / (1 + SUM (G, TAUM (G,I)))

This is the exogenous price in external markets. To get the external "real price" we must remove the impact of import duties. Note that units of a good are defined such that it costs a dollar in the initial equilibrium. For external goods this dollar includes the import duty; therefore, the net of tax cost is reduced by import duties.

TAUM(G,I) is the import duty on sector I goods paid to government sector G.

P0(I) = 1 is the aggregate price for sector I goods.

PD0(I) =1 is the domestic price for sector I goods.

6.6 Initial Numbers of Households and Transfer Payments

HW0(H) = MISCH(H,'HWO')

We set the initial number of working households for each type of household H equal to the value found in the matrix MISCH(H,'HW0'), in the MSC9900.prn data set.

Note that working household data comes from tax return data; therefore, there will be workers in the '0' bracket that don't file returns and thus are not counted as working.

ALPHALS(H,L) = ALPHAL(H,L) / SUM(LL, ALPHAL(H,LL))

ALPHALS(H,L) is the imposed share of labor type by household type (i.e., this is the fraction of households of type H that supply type 'L' labor).

ALPHAL(H,L) is the fraction of households of type ‘H’ that supply type ‘L’ labor.

Each household has a unique type by both income level (indexed by H) and labor type (indexed by L) unless it is nonworking. SUM(LL, ALPHAL(H,LL)) is the total labor supply of all types supplied by household type H.

HH0(H) = MISCH(H,'HH0')

HH0(H) is the total number of households of type H. This is found in the matrix MISCH(H,’HH0’) in the MSC9900 data set.

HN0(H) = HH0(H) – HW0(H)

HN(H) is the number of nonworking households. It is equal to the number of households minus the number of nonworking households.

TP0(H,GW)$TPC(H,GW) = SAM(H,GW) / (HN0(H)*TPC(H,GW))

This defines the transfer payments GW per eligible household for household type H.

TP0(H,GW) is initial per eligible HH transfer payments

SAM(H,GW) is transfer payment GW received by households of type H.

HN0(H) number of nonworking HHs in group H.

TPC(H,GW) is the fraction of nonworking households of type H receiving transfer payments GW.

6.7 Factor Rentals: Rates and Quantities

R0(‘CAPIT’,G) = 1

Return on Capital for government unit G set equal to 1.

FDO(‘LABOR’,Z) = MISC(Z,’JOBS’)

Set initial demand for labor for sector Z equal to current employment in sector Z.

MISC(Z, ‘JOBS’) is the number of jobs reported for sector Z in the ES202 reports.

ALPHALD(I,L)$SUM(LL, ALPHAL(I,LL)) = ALPHAL(I,L) / SUM(LL, ALPHAL(I,LL))

ALPHALD(I,L) is the imposed share of labor type by industry sector (i.e., the fraction of industry I’s labor that is type LL labor).

SUM(LL, ALPHAL(I,LL)) is the sum of all labor used in industry sector I.

ALPHAL(I,LL) is number of labor type LL workers employed by industry I.

ALPHALD(G,L)$SUM(LL, ALPHAL(G,LL)) = ALPHAL(G,L) / SUM(LL, ALPHAL(G,LL))

ALPHALD(G,L) is the imposed share of labor type by government sector.

ALPHAL(G,LL)) is number of type LL workers employed by government sector G.

6.8 Market Rental Rates and Quantities of Factors

R0('LABOR',Z) = SUM(L, ALPHALD(Z,L) * W0(L))

R0(‘LABOR’, Z) is the weighted average unit cost of labor. Since we have several types of labor each with its own wage rate, we take a weighted average of the wage rates using as weights the fraction of total labor used by labor type.

ALPHALD(Z,L) is the fraction of sector Z’s labor that is labor type L.

W0(L) is the initial wage rate for type L labor. Note that the wage rate for type L labor is the same for all sectors.

FDO('CAPIT',I) = SAM('CAPIT',I) / R0('CAPIT',I)

FD0('CAPIT', I) is demand for capital by sector I.

We get this by the simple expedient of dividing the values in SAM for payments to capital by the rental rate, which are reasonably sector specific.

SAM('CAPIT', I) is payment to capital by sector I.

R0('CAPIT', I) is the rental cost of capital for sector I.

FD0('CAPIT',G) = SAM('CAPIT',G) / R0('CAPIT',G);

Demand for capital by government sector. Note that we set R0('CAPIT',G)=1. Consequently, factor demand is the amount of capital expenditures.

SAM('CAPIT', G) is capital expenditures by government unit.

KS0(I) = FD0('CAPIT',I);

KS0(I) is the capital stock for industry sector I. Since we assume the initial economy is in equilibrium, the capital stock must equal the demand for capital.

FD0('CAPIT', I) is defined above to be the demand for capital by industry sector I.

JOBCOR(L) = SUM(H, ALPHALS(H,L) * HW0(H)) / SUM(Z, ALPHALD(Z,L) * FD0('LABOR',Z));

We create a correction factor that defines the ratio of working households supplying type L labor to the total number of type L workers employed. This ratio will be less than one since there are more jobs than working households (i.e., some households have several workers). Note SUM(L, ALPHALS(H,L)) = 1 by construction.

The numerator is the supply of workers of type L:

ALPHALS(H,L) is the fraction of type H households that supply type L labor.

HW0(H) is the number of working households.

The denominator is the demand for workers:

ALPHALD(Z,L) is the fraction of sector Z's labor demand represented by labor type L.

FD0('LABOR',Z) demand for labor by sector Z. Note the denominator is the total demand for labor type L.

6.9 Shares Found in the Social Accounting Matrix

A(Z,Z1) $Q0(Z1) = SAM(Z,Z1) / Q0(Z1)

This creates a parameter that that measures the fraction of payment to sector Z by sector Z1. The fraction is expressed in terms of the fraction of all payments from this sector.

SAM(Z,Z1) is the total payments (in dollars) by sector Z1 to sector Z.

Q0(Z1) row and column total in SAM for sector Z1.

AG(I,G)$(SUM(J,SAM(J,G)) + SUM(F,SAM(F,G)) + SUM(GF,SAM(GF,G))) = SAM(I,G) / (SUM(J,SAM(J,G)) + SUM(F,SAM(F,G)) + SUM(GF,SAM(GF,G)))

Fraction of total government payments (excluding transfers to other government units) by government sector G to industry sector I.

SUM(J,SAM(J,G)) Payments by government sector G to industry .

SUM(F,SAM(F,G)) Payments by government sector G to factors.

SUM(GF,SAM(GF,G)) Payments by government sector G to factor taxes.

AG((F,G)$SUM(I,SAM(I,G)) + SUM(F1,SAM(F1,G)) + SUM(GF,SAM(GF,G))) = SAM(F,G) / SUM(I,SAM(I,G)) + SUM(F1,SAM(F1,G)) + SUM(GF,SAM(GF,G))).

Fraction of total payments by government sector G (excluding intergovernmental transfer payments) to factor F.

SAM(F,G) is payments by government sector G to factor F.

SUM(I,SAM(I,G)) is payments by government sector G to industry.

SUM(F1,SAM(F1,G)) is payments by government sector G to factors.

SUM(GF,SAM(GF,G)) is payments to government sector G to factor taxes.

6.10 Initial Levels for Macro Variables

CX0(I) = SAM(I,'ROW')

Exports by industry I.

M0(I) = SAM('ROW',I)/PW0(I)
PW0(I) = 1/ (1 + SUM(G, TAUM(G,)))

Imports of sector I products divided by prices adjusted by tariffs. SAM('ROW', I) does not include tariffs. Therefore, dividing by PW0(I) (a number less than one) gets expenditures including duty.

SAM('ROW', I) is expenditures on industry I imports.

V0(I) = SUM(J,SAM(I,J) / P0(I) / (1 + SUM(GS, TAUQ(GS,I))))

Purchases from industry sector I for goods and services produced by other industry sectors, or intermediate goods.

SUM(J,SAM(I,J)) is the sum of all industries' use of sector I outputs for use as intermediate inputs.

P0(I)/ (1 + SUM(GS,TAUQ(GS,I)) is the real before sales tax price for sector I goods.

SUM(GS,TAUQ(GS,I)) is the sum of all sales taxes on industry sector I goods.

P0(I) = 1 is the aggregate price for industry I goods.

CH0(I) = SUM(C, SAM(I,C) / P0(I)/ (1+(SAM(GS, TAUQ(GS,I))))

This is consumption of industrial sector I goods by households as composite commodities.

SUM (C, SAM(SAM(I,C)) is the share of purchases from sector I resulting from consumption of composite commodities.

P0(I) / (1 + SUM(GS, TAUQ(GS,I))) is the real after sales tax price of industry sector I goods.

CG0(I) = SUM(G, SAM(I,G) / P0(I) / (1 + SUM(GS, TAUQ(GS,I))));

CG0(I) is the real after sales tax government consumption of industry I goods.

SAM(I,G) = government expenditures on industry sector I by government unit G

SUM(GS,TAUQ(GS,I)) is the sum of all sales taxes on industry sector I goods.

P0(I) is aggregate price for industry sector I.

GSP0(G) = SUM(I, SAM(I,G)) + SUM(F, SAM(F,G)) + SUM(GF, SAM(GF,G));

GSP0(G) is nominal government spending on goods and services by government unit G including factors and factor taxes. Note this excludes intergovernmental transfers.

SAM(I,G) is government sector G spending on industry sector I goods.

SAM(F,G) is government sector G spending on factor F.

SAM(GF,G) is government sector G spending on factor tax GF.

ALPHACG(Z,G)$GSP0(G) = SAM(Z,G) / GSP0(G);

This equation defines the fraction of total government payments (GSP0(G) excludes intergovernmental transfers) by sector G going to sector Z.

GSP0(G) is nominal government spending on goods and services by government unit G including factors and factor taxes. Note this excludes intergovernmental transfers.

SAM(Z,G) is government sector G payments to sector Z.

DEPR = SUM(I, SAM(I,'INVES')) / SUM(I, KS0(I));

DEPR measures the economy-wide average depreciation rate that in equilibrium is assumed to equal investment divided by the capital stock (I.e., all investment is assumed to just cover depreciation)

SUM(I, SAM(I, ‘INVES’)) is the sum of all industry investment.

SUM(I, KS0(I)) is sum of all industries capital stock.

KS0(I) is capital stock of industry sector I.

N0(I) = KS0(I)*DEPR

Gives investment by sector I equal to the average depreciation rate for the economy multiplied by the capital stock for sector I.

KS0(I) is initial capital stock in industry sector I.

DEPR is economy wide depreciation rate.

CN0(I) = SUM((J, CCM(I,J)*N0(J)) / P0(I) / (1 + SUM(GS,TAUQ(GS,I)))

Expenditures on sector I capital goods by all industries.

CCM(I,J) Is the fraction of industry sector I’s output used in an average unit of the industrial sector’s J’s capital stock

N0(J) is sector J’s investment expenditures.

P0(I) is aggregate price index for sector I output.

(1 + SUM(GS,TAUQ(GS,I)) is the price index for sector I adjusted to include sales tax rates.

DD0(I) = CH0(I) + CG0(I) + CN0(I) + V0(I);

DD0(I) is aggregate demand for sector I which is the sum of household consumption, exports, government purchases, investment, and intermediate inputs.

CH0(I) is expenditures on sector I's commodities resulting from household purchases of composite commodities.

CG0(I) is expenditures by government on goods and services from sector I.

CN0(I) is expenditures on capital goods purchases from sector I.

V0(I) is purchase of sector I goods for intermediate inputs.

DS0(I) = SUM(J, SAM(J,I)) + SUM(F, SAM(F,I)) + SUM(GF, SAM(GF,I));

DS0(I) is aggregate supply for industry sector I. Note that the supply of industry I is the sum of all it's payments (i.e., every dollar of revenue is either payment to suppliers, factors or factor taxes).

6.11 Production Data

AD(I,J) = SAM(I,J) / P0(I)/ (1 + SUM(GS , TAUQ (GS, I)))/DS0(J)

Fraction of industry sector I's demand resulting from production of sector J's output (i.e., I's use as an intermediate input for sector j.)
P0(I) is the aggregate price of sector I.
(1 + SUM(GS , TAUQ (GS, I))) is the price index for sector I adjusted for sales tax.
DS0(I) is the aggregate supply for sector I.

PVA0(I) = PD0(I) – SUM(J, AD(J,I)*P0(J)*(1 + SUM(GS,TAUQ(GS,J))))

Price of value added in industry sector I.
PD0(I) is the domestic price of sector I.
SUM(J, AD(J,I)*P0(J)*(1 + SUM(GS,TAUQ(GS,J)))) is the sum of all cost for intermediate products used in the production of one unit of I adjusted with sales tax.

E0(I) = 1

E0(I) is impact of government infrastructure on private productivity.

GST0 = SUM(GNS, KAPPA(GNS) * GSP0(GNS)

Total government spending on infrastructure.
Kappa is policy weight for sector I. Note that currently there are two sectors in GNS, local and state spending on transportation that affect infrastructure. Each is given equal weight in the infrastructure (KAPPA = 1). However, at some point we may want to assignment different weights for different types of spending in infrastructure (e.g., education may improve infrastructure – human capital).
GSP0(GNS) is total government spending on infrastructure sector goods.

6.12 Miscellaneous Initial Data

NKI0 = SAM('INVES', 'ROW')

Net Capital Inflow

Y0(F) = Q0(F)

Factor Income (Q0(F) is factor row or column total)

Y0(H) = SUM(F,SAM(H,F))

Factor income paid to households.

A(H,F) = SAM(H,F) / Y0(F) / HW0(H)

This is the share of factor income paid to type H households, per household.
SAM(H,F) is factor income paid to all households of type H.
HW0(H) is the number of households of type H.
Y0(F) is total factor F income.

TAUH(GH,H) = SAM(GH,H) / HH0(H)

Household type H per capita household tax GH (note domain only includes household taxes)

S0(H) = SAM('INVES', H)

Savings by household type H.

YD0(H) = SUM(C,SAM(C,H)) +S0(H)

Disposable income for households of type H.
SUM(C,SAM(C,H)) is total consumption spending by households of type H.
S0(H) is savings by households of type h by households of type H.

Y0(G) = SUM(Z, SAM(G,Z)) –SUM(G1, IGT0(G,G1))

Nominal government income excluding intergovernmental transfers.
SAM(G,Z) is payment to government sector G from sector Z.
IGT0(G,G1) intergovernmental transfers from government sector G1 to sector G.

HFI0(H, 'CAPIT') = SAM(H, 'CAPIT') / HW0(H)

HFI0(H, 'CAPIT') is per working household factor income from capital.
HW0(H) is number of working households.

HFI0(H,'LABOR')=SUM(L,ALPHALS(H,L)*W0(L)/JOBCOR(L))*(1–SUM(G,TAUFH(G,'LABOR')))

HFI0(H, 'LABOR) is the per household factor income from labor for household type H.
ALPHALS(H,L) is the proportion of working household type H supplying type L labor.
W0(L) is the wage rate of type L labor. Since we divide by JOBCOR(L) to get the household labor income, W0(L) must be in per worker terms.
JOBCOR(L) corrects the number of working households to jobs. It is less than one by construction (i.e., there are more jobs than working households).
TAUFH(G,'LABOR') is household factor tax payments (i.e., household share of Social security payments).

AGIO(H) = SUM(F, OMEGA(F) * HFIO(H,F))

AGIO(H) is adjusted gross income for PIT purposes.
OMEGA(F) is the rate at which factor incomes are exposed to income taxes. It is a manually inputted value in the 9900 worksheet.
HFIO(H,F) is household type H income from factor F.

SPI0 = SUM(H,Y0(H)) + SUM((H,GW),TP0(H,GW) * HN0(H)*TPC(H,GW))

This is state personal income, chosen as the objective—its elements follow roughly the Bureau of Economic Analysis, Department of Commerce (http://www.bea.doc.gov).

Y0(H) is sum of factor incomes for households of type H (i.e., sum of labor and capital income).
TP0(H,GW) is the transfer payment from government unit GW to per eligible household of type H.
HN0(H) is the number of non-working households of type H.
TPC(H,GW) percent of household type H receiving transfer payment GW.

PIT0(GI,H)) = SAM(GI,I) / HWO(H)
Income tax GI per type H working household. GI = {LTPRP,CTPIT,FTPIT}

TAXBASE('LTPRP', 'HOUS0', 'TAXBASE') = MISCG('LTPRP', 'HOUS0', 'TAXBASE') / HW0('HOUS0')* MISCH('HOUS0', 'HW0')
TAXBASE('LTPRP', 'HOUS0', 'TAXBASE') is the base local property tax payment amount per type HOUS0 household.
MISCG('LTPRP', 'HOUS0', 'TAXBASE') local property tax payments by household type HOUS0 households.
HW0('HOUS0') is number of working households of type HOUS0.

MI0(H) = 0.09*HH0(H)

MO0(H) = 0.09*HH0(H)
These are in-migration and out-migration, but five or six years' worth.

6.13 Investment Tax Credits and Correction to Gross California Profits Taxes.

FITC(F,G) = 0
Defaults allocation of factor taxes.

FITC('CAPIT', 'CTBAC') =1
Allocation of CTBAC investment tax credit to 'CAPIT'. An increase in the investment tax credit for California is applied exclusively to CTBAC.

ITC0(I) = SUM(J,N0(I) * CCM(J,I) / (1 + SUM(GS, TAUQ(GS,J)))* ITCE(J,I))
Investment tax credit in dollars.
N0(I) is sector I gross investment, which is equal to depreciation (5% of industry capital stock).
CCM(J,I) is the share of an investment dollar of industry I spent on goods from industry J.
SUM(GS,TAUQ(GS,J))) Sum of the sales tax rates on industry J commodities.
ITCE(J,I) is eligibility for investment tax credit (found in MSC9900.prn file).

TAUF('CTBAC', 'CAPIT',I) = (SAM('CTBAC',I) + ITC0(I)) / SAM('CAPIT',I)
Factor-tax rate for factor CAPIT paid to CTBAC by sector I.
SAM('CTBAC', I) is payments to CTBAC by industry sector I.
ITC0(I) is investment tax credit for sector I. We add ITC0(I) because it reduces the CTBAC tax owed and not adding it back in would cause the factor tax rate to be under-stated.

TAUFX('CTBAC','CAPIT',I) = TAUF('CTBAC', 'CAPIT', I)
Experimental factor tax rates equal to actual factor tax rates in the base case.

6.14 CES Production Function Calibration

ALPHA(F,I)=(SAM(F,I)+SUM(GF,TAUFF(GF,F)*SAM(GF,I)))/(SUM(F1,SAM(F1,I))+SUM(GF, SAM(GF,I)))

These are factor share coefficients in the production function.
SUM(GF, TAUFF(GF,F)*SAM(GF,I)) is amount of factor taxes paid for factor F in industry I to all government units that collect factor tax on factor F.
Note that TAUFF is equal to 1 if factor F pays factor tax to government factor tax unit GF and equal to 0 otherwise.
SUM(F1,SAM(F1,I)) is the total of payments to factors by industry I.
SUM(GF, SAM(GF,I)) is the total factor tax paid by industry I to all government factor tax units.

RR0(F,I) = R0(F,I) *(1 + SUM(GF,TAUFX(GF,F,I))) – SUM(GF,FITC(F,GF) *ITC0(I))/ FD0(F,I)

This is the rental rate for factor F by sector I (including taxes). The last term is divided by factor demand to blend the factor tax credit for industry I into the rate.
R0(F,I) is rental rate for factor F by sector I.
SUM(GF,TAUFX(GF,F,I) is the sum of factor taxes on factor F paid by sector I.
ITC0(I) is the investment tax credit in dollars for industry I.
FITC(F,G) is the applicability investment tax credit to factors.
SUM(GF,FITC(F,GF) *ITC0(I)) is the dollar total of investment tax credit for industry I for factor F.

6.15 Initial Calibration of Consumption Functions

SIGMAH(H) = SAM('INVES', H) / YD0(H)

This is the average propensity to save (average savings rate). Note that this is a crude representation of savings, but will have to do for now.
SAM('INVES', H) is the dollar amount household H contributes to investment (savings).
YD0(H) is disposable income.

CS0(C,H) = SAM(C,H) / SUM(C1, SAM(C1,H))

Share of total consumption expenditures by household H on composite commodity C.

BETA('CFUEL') = BETA('CFUEL') – SUM(C1, BETA(C1))

Sets the income elasticity for fuel so that the sum of price elasticities equals 0.
Note that the BETA('CFUEL') on the right cancels out with the -BETA('CFUEL') found in the sum on the right where BETA(C1) is the income elasticity of demand for composite commodity C1.

ALPHA0(C,H) = CS0(C,H) – BETA(C) * LOG(YD0(H) * (1-SIGMA(H)))

ALPHA0(C,H) is the constant in the LA-AIDS consumption function.
CS0(C,H) is the initial consumption expenditures on composite commodity C by household type H.
BETA(C) is the income elasticity for composite commodity C.
YD0(H) is after-tax, or disposable, income.
SIGMA(H) is average (and marginal) propensity to save.

PHI(I,C) = SAM(I,C) / SUM(J, SAM(J,C))

These are distributional shares of composite commodity to industry sector.

LOOP(C, LOOP(C1$(ORD(C1) GT ORD(C)), LAMBDA(C,C1) = LAMBDA(C1,C)))

LAMBDA(C1,C) is a parameter related to the cross price elasticity of demand.

The LOOP function is used to assign values for cross elasticities that aren't defined in the data set (i.e., in the data set the matrix of elasticities is lower triangular).

Suppose that ORD(C) = 1 (i.e., it is the first commodity in the list), then the embedded LOOP compares ORD(C1) with ORD(C)).

If ORD(C1) > ORD(C), then the cross price elasticities for the upper triangle get set so that the cross price elasticities are symmetric.

LAMBDA(C1,C) is a parameter in the MISC data set.

LAMBDA(C,C) = LAMBDA (C,C) –SUM(C1, LAMBA(C1,C))

This sets a parameter related to the own price elasticity. The definition forces the sum of parameters (related to own and cross price elasticities) to equal zero. See paper on LA/AIDS estimation.

6.16 Initial Government Spending on Public Education

GSK140 = SUM(G, IGT0('LSK14',G))

Government spending on K-14 public education.

IGT0('LSK14', G) is intergovernmental transfer from government unit G to K-14 education.

GSUNIO = SUM(G, IGTO('CSUNI', G))

Government spending on university education.

IGTO('CSUNI', G) is intergovernmental transfers from government unit G to universities.

GFREV0 = Y0('CGENF') + SUM(G, IGT0('CGENF', G))

General fund revenue.

Y0('CGENF') is direct payments to the California general fund (i.e., the row total for CGENF in the SAM).

IGT0('CGENF', G) is intergovernmental transfers from government unit G to the general fund.

SFREV0 = SUM(GSF, Y0(GSF) – IGTO('CGENF', GSF))

This is total revenue for all special funds.

Y0(GSF) is the row total for each special fund unit GSF in the SAM.

IGT0('CGENF',GSF) is intergovernmental transfers from special fund unit GSF to the general fund.

7 Equations

7.1 Households

7.1.1 Consumer Price Indices

LOG(P(H)) =E= SUM(C, CS(C,H)*LOG (P(C)))

This expression comes from LAAIDS framework for the price index in the consumption shares equation.

CS(C,H) is consumption share of composite commodity C consumed by household type H.

P(C) is the price of composite commodity C defined in 1.06.

7.1.2 Household Labor Income

HFI(H,'LABOR')=E=SUM(L,ALPHALS(H,L)*W(L)/JOBSCOR(L))*(1-SUM(G,TAUFH(G,'LABOR')))

This equation is for household labor income net of factor taxes paid by households on labor income.

ALPHALS(H,L) is the fraction of total type H households that supply type L labor.

W(L) is wage rate for type L labor.

JOBCOR(L) corrects for fact that there are fewer working households earning wage rate W(L) than there are workers that are earning W(L) wages.

TAUFH(G, 'LABOR') is factor tax on labor paid by households. Note that this is nonzero only for G = FTSOC.

7.1.3 Household Capital Income

HFI(H, 'CAPIT') = A(H, 'CAPIT') / SUM(H1, A(H1,'CAPIT') *HW(H1)) * Y('CAPIT')

This equation distributes capital income to households.

A(H,F) is SAM(H,F)/(Y0(F)/HW(H)).

Y0(F) is initial income for factor F.

HW(H1) is number of working households in household category H1.

Y('CAPIT') is economy-wide capital income.

7.1.4 Household Gross Income

Y(H) =E= SUM(F, HFI(H,F)) *HW(H)

This equation establishes that gross household income is the sum of labor income plus capital income.

HFI(H,F) is the income from factor F attributed to household H.

HW(H) is the number of working type H households.

7.1.5 Household Gross Income

YD(H) =E= Y(H) –SUM(GI, PIT(GI, H)) * HW(H) – SUM(G, TAUH(G,H) * HH(H)) + SUM(G, TP(H,G) * HN(H) * TPC(H,G))

Y(H) is household type H income defined in 1.02.

SUM(GI, PIT(GI,H)) is the sum of various personal income taxes paid to the federal, state, and local governments.

TAUH(G,H) are household taxes other than PIT.

SUM(G,TP(H,G) * HN(H) *TPC(H,G)) is the sum of transfer payments to household h from all sources.

TP(H,G) is per eligible household transfer payment for household type H from government sector G.

HN(H) is number of nonworking households of type H.

TPC(H,G) is fraction of nonworking households of type H getting transfer payments from government sector G.

7.1.6 Household Consumption Shares

CS(C,H) = ALPHA0(C,H) + SUM(C1, LAMBDA(C1,C) * LOG(P(C1))) +BETA(C)*LOG(YD(H) * (1 – SIGMAH(H)) / P(H)

Consumption shares equation directly from LA/AIDS model except subtract savings from disposable income.

ALPHA0(C,H) is the constant in the LA/AIDS consumption share equation.

LAMBDA(C1,C) is a parameter measuring impact on consumption resulting from a change in price.

P(C1) is consumer prices for commodity C1.

BETA(C) is a parameter.

YD(H) is disposable income.

SIGMAH(H) is a parameter (average propensity to save).

P(H) is consumer price index for household H.

7.1.7 Total Consumption of Goods and Services by Households

CH(I)=E=SUM(C,PHI(I,C)*SUM(H,CS(C,H)*(YD(H)–S(H))))/(P(I)* (1+SUM(GS,TAUQX(GS,I))))

This equation converts purchases of composite commodities into purchases from the more detailed industry sectors.

PHI(I,C) is the fraction of a dollar spent on industry I commodities for each dollar spent on composite commodity C.

S(H) is total dollars saved by all type H households.

YD(H) is disposable income for all type H households.

CS(C,H) is consumption shares for households of type H.

TAUQX(GS,I) is experimental sales tax rate paid by industry I to government sales tax authority GS.

7.1.8 Composite Commodity Prices

P(C)=E=SUM(I,PHI(I,C)*P(I)*(1+SUM(GS,TAUQX(GS,I))))/SUM(I,PHI(I,C)*P0(I)*(1+TAUQ(GS,I))))

This is straightforward, all items are explained in 1.05, except P(I) which is the price for industry sector I commodities.

7.1.9 Household Savings

S(H) =E= SIGMAH(H) * YD(H)

SIGMAH(H) is average propensity to save.

YD(H) is disposable income.

7.2 Producers

7.2.1 Value Added Price

PVA(I) =E= PD(I) – SUM(J, AD(J,I) * P(J) * (1 + SUM(GS, TAUQX(GS,J))))

Price of value added is the sales price of output minus the cost of intermediate inputs (i.e., revenue is total cost of intermediate inputs plus value added).

PD(I) is domestic price for industry I's commodities (excluding taxes).

AD(J,I) Is the intermediate use of J's input for a unit of I's output.

TUAQX(GS, J) is experimental sales tax on J.

7.2.2 Unit Cost Function

PVA(I)=E=1 / E(I) * PVA0(I) * SUM(F, ALPHA(F, I) * (RR(F,I) / RR0(F,I)) ** (1 – SIGMA(I))) ** (1 / (1 - SIGMA(I)))

This is difficult to derive and is taken out of " Constant Elasticity of Substitution, Some Hints and useful Formulae" by Thomas Rutherford. Note that solving require 2.02 to generate PVA(I) consistent with equation 10.

E(I) is the infrastructure scale variable.

PVA0(I) is the price of value added defined by 2.02.

ALPHA(F,I) is the share of factor F used to produce unit of commodity I. Note that sum of alphas equal 1.

SIGMA(I) is the elasticity of factor substitution.

7.2.3 Total Government Spending

GST =E= SUM(GNS, KAPPA(GNS) * GSP(GNS))

GST is government on infrastructure that improves private productivity. .

KAPPA(GNS) is policy weights for government infrastructure spending. It is set to 1.

GSP(GNS) is nominal government spending on goods and services including factor rentals and taxes.

Note make a new set GINFR (a subset of G) consisting of LSTRA and CSTRA.

7.2.4 Infrastructure Variable

E(I) =E= E0(I) * (GST/GST0) ** ETAGS(I)

E(I) is a variable which determines the improvement to private productivity for a specific infrastructure expenditure level.

ETAGS(I) is set to 0.1.

GST is the gross spending on infrastructure.

7.2.5 Rental Rates for Factors

RR(F,I) =E= R(F,I) * (1+ SUM(GF,TAUFX(GF,F,I))) – SUM(GF, FITC(F,GF) * ITC((I))/ FD(F,I)

RR(F,I) is the tax inclusive rental rate for factor F by industry sector I.

R(F,I) is the rental rate after factor tax for factor F in industry I.

TAUFX(GF,F,I) is the experimental factor-tax rate on factor F by factor-tax unit GF.

FITC(F,GF) is the allocation of investment tax credit to factors.

ITC(I) is the investment tax credit to industry I.

FD(F,I) is the demand for factor F by industry I.

7.2.6 Factor Demand

FD(F,I) =E= E(I) * FD0(I) * DS(I) / DS0(I) * ((RR0(F,I) * PVA(I)))/ (RR(F,I) * PVA0(I))) ** SIGMA(I)

E(I) is infrastructure scale variable see equation 2.04.

DS(I) is supply of industry I.

RR(F,I) is after BAC tax rate of return defined in equation 2.05.

PVA(I) is price of value added defined in equations 2.01 and 2.02.

7.2.7 Demand for Intermediate Goods and Services

V(I) =E= SUM(J, AD(I, J) * DS(J))

By multiplying the fraction spent on real industry I inputs (not including expenditures of sales taxes) per real unit of industry J output and summing over all industries J, we get the total real value of industry I output used as an intermediate input.

AD(I, J) Is the before tax expenditure on inputs from industry I by industry J per unit production of industry j not including sales taxes.

DS(J) is the real before sales tax supply (output)of industry J.

7.2.8 Factor Income

Y(F) =E= SUM(Z, R(F,Z) * FD(F,Z))

This is the real after tax factor income for factor.

R(F,Z) Is the rental rate after factor tax for factor F, in sector Z.

FD(F,Z) is the demand for factor F by sector Z.

7.2.9 Labor Rate by Sector of Demand

R('LABOR', Z) =E= SUM(L,ALPHAD(Z,L)*W(L))

This equation calculates the after factor tax rate-of-return on labor in sector Z.

ALPHAD(Z,L) is the fraction of labor demand, in sector Z, for type L labor.

W(L) is the wage rate for type L workers.

7.3 Trade

7.3.1 Export Demand

CX(I) =E= CX0(I) * (PD(I) / PD0(I)) ** ETAE(I)

CX0(I) are initial exports.

PD(I) is domestic price for industry I.

ETAE(I) is a demand elasticity parameter.

7.3.2 Import Supply

M(I) = E= MO(I) * (PD(I)/ PD0(I)) **ETAM(I)

M0(I) are initial imports. (See equation 19 for the remaining variables.)

7.3.3 Average Price faced by Domestic Consumers

P(I)=E=((DS(I)–CX(I))*PD(I)+M(I)*PW0(I)*(1+SUM(G,TAUM(G,I))))/(DS(I)–CX(I)+M(I))

Weighted average of domestic commodity consumption and import consumption.

DS(I) is domestic supply.

CX(I) is export consumption.

PD(I) is domestic price.

PW0(I) is world price not including import tariffs.

M(I) is imports.

7.3.4 Net Capital Inflow

NKI =E= SUM(I, M(I) * PWO(I)) –SUM(I, CX(I) *PD(I))

Net capital inflow is the value of imports paid to the rest of the world (ROW, which includes the rest of the U.S.) minus the dollar value of exports received from the ROW.

M(I) are imports of sector I goods.

PW0(I) is world price for sector I goods.

CX(I) is consumption of exports in sector I.

PD(I) is the domestic price of sector I goods.

7.4 Investment

7.4.1 Investment by Sector of Destination

N(I) =E= KS(I) * DEPR

In equilibrium real investment this equals depreciation.

KS(I) is capital stock.

DEPR is depreciation rate (assumed to be 5 percent).

7.4.2 Investment by Sector of Source

P(I) * (1 + SUM(GS,TAUQX(GS,I))) * CN(I) =E= SUM(J, CCM(I,J) * N(J))

Total nominal investment expenditures including sales taxes on goods from industry I.

P(I) is price of sector I goods or services.

SUM(GS, TAUQX(GS,I)) is the sum of experimental sales tax rates on sector I goods.

CN(I) is the real after tax investment expenditure on sector I commodities.

CCM(I,J) is the fraction of sector I commodities per dollar investment by sector J.

N(I) is the nominal investment by sector J.

7.4.3 Desired Capital Stock

KSEQ(I) .. KS(I) =E= KSO(I) * (R('CAPIT',I) /R0('CAPIT',I)) ** ETAI(I)

Desired capital stock increases with an increase in the rate of return of capital.

KS0(I) initial capital stock in industry I.

R('CAPIT',I) rental rate of capital.

7.4.4 California Investment Tax Credit Earned

ITC(I) =E= SUM(J, N(I) *CCM(J,I) / (1 + SUM(GS,J))) * ITCE(J,I))

Investment tax credit earned is determined by finding each industry's gross investment purchases from each sector, multiplied by the applicable rate for investment tax credit for the source and destination industry commodities.

Division by (1 + SUM(GS,J)) is performed to remove sales taxes from gross purchases.

ITCE(J,I) is the eligibility for investment tax credit, and is found in the MSC9900.prn file. This rate is 0, 3 or 6% for given combinations of source and destination industries.

CCM(I,J) is the capital coefficients matrix described in 4.02 above.

N(I) is nominal investment spending, which includes sales taxes.

7.5 LABOR SUPPLY AND MIGRATION

7.5.1 Labor Supply

HW(H) / HH(H) =E= HW0(H) / HH0(H) * ((HFI(H, 'LABOR') / HFI0'LABOR')) / ((P(H) / P0(H)))ETARA(H) * ((1 +SUM(GI, MTR(GI,H)*TAXCVCX(GI,H))) / (1+SUM(GI, MISCG(GI,H, 'MTR')*TAXCVC(GI,H)))) **ETAPIT(H) * (SUM(G,TP(H,G)/ P(H)) / SUM(G, TP0(H,G)/P0(H)))**ETATP(H)**

The fraction of households working is equal to the fraction working in original equilibrium multiplied by three things:

- First, a function of real wages (excluding taxes) is raised to an exponent measuring the labor supply elasticity of real wages.
- Next, a function of personal income taxes.
- The final product is transfer payments raised to an exponent measuring the elasticity of offers to work with respect to transfer payments.

HW(H) is working households.

HH(H) is total households.

P(H) are the consumer price indices.

TAXCVCX(GI,H) experimental tax constant to correct observed taxes to actual taxes.

TAXCVC(GI,H) is original tax correction factors.

MISCG(G,H,'MTR') is original marginal tax rates for household H and government tax G.

MTR(GI,H) is marginal tax rate for household H and government tax G1.

TP(H,G) is transfer payments

7.5.2 Population

HH(H) =E= HH0(H) *NRPG(H) + MI0(H) * ((YD(H) / HH(H)) / YD0(H) / HH0(H)) / (P(H)/ P0(H))) **ETAYD(H) * ((HN(H) / HH(H) / HN0(H) / HH0(H))) **ETAU(H) ((GSK14 + GSUNI / (GSK140 +GSUNI0)) **ETAED(H) – MO0(H) * ((YDO(H) / HH0(H)) / (YD(H) / HH(H)) / (P0(H) / P(H))) **ETAYD *((HN0(H) / HH0(H)) / HN(H) / HH(H))) ** ETAU(H) *((GSK140 + GSUNI0)/(GSK14 + GSUNI)) ** ETAED(H)

Net migration is a function of the natural rate of population growth, in-migration and out-migration.

In-migration consists of a coefficient (MI0(H)=9% of current population, a figure deemed appropriate for five or six years of migration), multiplied by ratios for real disposable income, unemployment, and a measure of education amenities. Each of these terms is expressed in a change raised to a power, which stands for the elasticity.

Out-migration is structured much the same as in-migration, with the fractions flipped.

HH(H) is the number of households in category H.

NRPG(H) is the natural rate of population growth.

MI0(H) is in-migration.

YD(H) is disposable income.

P(H) is consumer price index.

HN(H) is the number of nonworking households.

GSK14 is the total state and local education spending on K-14 education.

GSUNI is total state university spending.

7.5.3 The Number of Non-Working Households

HN(H) = HH(H) – HW(H)

We leave the interpretation of this equation to the reader. If you understood the two equations that preceed it (numbers 27 and 28), this one will be obvious.

7.6 Household Income Taxation

7.6.1 Adjusted Gross Incomes

AGI(H) =E= SUM(F, OMEGA(F) * HFI(H,F))

This equation defines adjusted gross incomes for computing personal income taxes.

OMEGA(F) is fraction of factor income which appears in AGI equation.

HFI(H,F) factor F income for household type H.

7.6.2 Income Taxes

PIT(GI,H) =E= (TAXBASE(G1,H) + AGI(H) – TAXBM(G1,H) –TAXSD(G1,H) – (TAXOD(GI,H) + SUM(GI1, ATAX(GI1,GI) * PIT(GI1,H))) * TAXPI(GI,I)) * MTR(GI,H)) * TAXCVCX(GI,H) – TAXCRED(GI,H)

TAXBASE(G1,H) is the amount of tax paid for household at the lowest taxable income for a given household type H. Note that local property taxes are modeled as income tax, to mimic the U.S. and California tax systems.

AGI(H) is per household adjusted growth income.

TAXBM(G1,H) is the minimum taxable income to be in this tax bracket (household type H).

TAXSD(GI,H) is the per household standard deduction for all households who are type H including those who itemize.

TAXOD(GI1,H) is other deductions per return.

ATAX(GI1,GI) deductibility of tax.

PIT(GI1,H) per itemizing household H personal income tax paid to government tax authority GI1.

TAXPI(G,H) percent of this household type who itemize.

MTR(GI,H) Marginal tax rate for bracket H.

TAXCVCX(GI,H) Experimental tax constant to correct to observed taxes (i.e. calculated taxes are in general different from taxes paid.

7.7 Government

7.7.1 Government Incomes

YGEQ(G) .. Y(G) =E= SUM ((I,J), TAUQX(G,I) * P(I) * AD(I,J) * DS(J)) +SUM(I, TAUM(G, I) * M(I) *PW0(I)) + SUM(I, TAUQX(G, I) * CH(I)* P(I)) + SUM(I, TAUQX(G,I) * CN(I) * P(I)) + SUM((G1, I), TAUQX(G, I) *CG(I, G1) * P(I)) + SUM((F, I), TAUFX(G, F, I) * *R(F, I) * FD(F,I) + SUM(F,G1, TAUFX(G,F,G1) * R(F, G1) * FD(F, G1) + SUM(F, TAUFH(G,F) * Y(F)) + SUM(H, PIT(G, H) * HW(H)) + SUM(H, TAUH(G,H) * HH(H)) +SAM(G, 'INVES') – SUM((I,F), FITC(F,G) * ITC(I)

This is made up of twelve items:

- Sales tax collected from sales of intermediate inputs.
- Import duties collected.
- Sales tax collected from household consumption.
- Sales tax collected on investment goods.
- Sales tax collected on government purchases.
- Factor taxes paid by business.
- Factor taxes paid by government.
- Factor taxes paid by households.
- Personal income taxes.
- Household taxes other than PIT.
- Investment payments to government (is equal to 0).
- Subtracting out investment tax credits.

TAUQX(G,I) is experimental sales and excise tax rates.

P(I) is aggregate price.

AD(I,J) is domestic input/output coefficient.

DS(J) is domestic supply.

TAUM is import duty rates.

M(I) are imports.

PW0(I) is world price.

TAUQX is the experimental price level.

CH(I) is the private consumption total.

CN(I) is gross investment by sector of source.

CG(I,G1) is government consumption.

TAUFX is experimental factor tax.

R(F,I) is rental rate for factor in industry I.

FD(F,I) is factor demand.

TAUFH(G,F) is the employee portion of factor tax.

Y(F) is total factor income.

PIT(G,H) is personal income tax.

HW(H) is the number of working household.

TAUH(G,H) are household taxes other than PIT.

FITC(F,G) is the allocation of investment tax credit to factor.

ITC(I) is investment tax credit to factor .

7.7.2 Government Spending - Endogenous

GSP(GN) = E = Y(GN) + SUM(G, IGT(GN,G) – IGT(G, GN)) – SUM(H, TP(H, GN) * HN(H) * TPC(H, GN)) – S0(GN)

GSP(GN) is nominal government spending on goods and services by endogenous government unit GN.

Y(GN) is the row (also column) total in the SAM for endogenous government sector GN.

SUM(G, IGT(GN,G) – IGT(G, GN)) is net in transfers from other government units.

TP(H, GN) is nominal per eligible household transfer payments from GN to households in group H.

TPC(H,GN) is fraction of nonworking households collecting transfer payment.

HN(H) is nonworking households of type H.

S0(GN) is savings by government unit GN.

7.7.3 Government Spending - Exogenous

GSP(GX) = E = GSP0(GX)

Exogenous government spending is fixed at original levels.

7.7.4 Summary Government Consumption

CG(I) =E= SUM(G, ALPHACG(I,G) *GSP(G)) / P(I) / (1 + SUM(GS, TAUQX(GS,I)))

CG(I) is consumption by government unit G of goods and services.

ALPHACG(I,G) is share of government sector G’s expenditures going to sector I.

GSP(G) is total government sector G spending on goods and services.

P(I) is aggregate price for sector I commodities.

TAUQX(GS,I) is sales tax rate on sector I commodities paid to sales taxing unit GS.

7.7.5 Endogenous Government Factor Rentals

FD(F,GN) =E= ALPHACG(F,GN) * GSP(GN)

Government unit GN’s factor demand is derived spending on goods and services by sector GN multiplied by a variable which relates the amount of factor F necessary to maintain the expenditure level.

ALPHACG(F,GN) is the share of a dollar that factor F represents of a dollar spent by GN.

GSP(GN) is nominal spending on goods and services by government unit GN.

7.7.6 Exogenous Government Factor Rentals

FD(F,GX) * R(F,GX) =E= FD0(F,X) * R0(F,GX)

Nominal expenditures on factors are constant. Since nominal expenditures by exogenous government units are fixed and equation 7.04 allocates spending on goods and services at a constant rate, nominal spending on factors remains fixed.

FD(F,GX) is real factor demand for factor F by exogenous government unit GX.

R(F,GX) is the nominal rate of return (before tax) for factor F employed by exogenous government sector GX.

7.7.7 Distribution of Revenues to Spending Units

IGT(G, GT) =E= TAXS(G, GT) * Y(GT)

This equation determines the funding of government spending units from a taxing unit.

TAXS(G, GT) is the share of taxing unit GT's transfers to government unit G. Note that in calculating the share of taxing unit GT's inflows going to each spending unit, the cost of GT's factor costs are excluded.

Y(GT) is row sum for sector GT in the SAM.

7.7.8 Distribution from Sources of Transfer Payments

IGT(GW,G1)=E= IGT0(GW, G1) + SUM(H, HN(H) * TP(H, GW)* TPC(H,GW)) – SUM(H, HN0(H) * TP0(H, GW) * TPC(H, GW))

If IGTD(GW,G1) equals 4, then intergovernmental transfer payment from government sector G1 to government transfer payment sector GW is equal to original intergovernmental transfer from G1 to GW plus the sum of transfer payments to eligible households of type H minus the sum of original transfer payments from GW to households H. (Endogenous transfer payments.)

TP(H, GW) is nominal per eligible household transfer payments from GW to households in group H. HN(H) is nonworking households (assumed to be the eligible households).

TPC(H,GN) is fraction of nonworking households collecting transfer payment.

7.7.9 Balance of General Fund Spread Proportionately

IGT(GC, 'CGENF') =E= (Y('GENF') + SUM(G, IGT('CGENF', G)) – SUM(GL, IGT(GL, ' CGENF')) –S0('CGENF)) * SAM(GC, 'CGENF) / SUM(GC1, SAM(GC1,'CGENF))

Transfers from the general fund equal the total of all payments to the general fund minus transfers from the general fund minus saving all multiplied by a factor that represents initial share of general fund spending by each spending unit.

IGT(GC,'CGENF') is intergovernmental transfers from the general fund.

Y('CGENF') is general fund tax receipts.

IGT('CGENF,G) is intergovernmental transfers to the California general fund.

IGT(GL,'CGENF) is intergovernmental transfers from the general fund to local government.

S0('CGENF') is initial general fund savings.

7.7.10 Government Savings

S(G)=E=Y(G)+SUM(G1,IGT(G,G1)–IGT(G1,G))–SUM(H,TP(H,G)*HN(H)*TPC(H,G))–GSP(G)

Government savings is equal to total tax revenue plus net intergovernmental transfers minus transfer payments from the unit to households.

Y(G) is tax revenue to G

IGT(G, G1) is intergovernmental transfers from other governmental units to G.

IGT(G1, G) is intergovernmental transfer from G to other governmental units.

TP(H,G) is per eligible household transfer payment.

HN(H) is number of none working households in household sector H.

TPC(H,G) is fraction of nonworking households receiving transfer payments.

GSP(G) Nominal spending on goods and services (including factor payments) by government sector G.

7.7.11 Proposition 98 Transfers to Education – Test 2

IGT('LSK14', 'CGENF') =E= IGT0('LSK14', 'CGENF') * ADA * (SUM(H,Y(H) + SUM(G, TP(H,G) * HN(H) * TPC(H,G))) / SUM(H, HH(H))) / SUM(H, Y0(H) + SUM(G, TP0(H,G) * HNO(H) * TPC(H,G))) / SUM(H, HH0(H)))

Test 2 establishes the transfer from the General Fund to local K-14 education as being a function of its present level, corrected by per capita personal income. The scalar applied is for Average Daily Attendance.

For each experiment conducted with the model, either this equation using test 2 or the equation immediately following (test 3) was used. In order to avoid solving a nonlinear mixed integer programming problem, it was decided to intervene in the application of Prop 98 manually.

IGT('LSK14, 'CGENF) is intergovernmental transfer from California general fund to K-14 education.

ADA is average daily attendance.

Y(H) is total household factor income.

TP(H) is per eligible household transfer payment.

HN(H) is number of nonworking households.

TPC(H,G) is the fraction of nonworking households receiving transfer payments.

HH(H) is number of households.

7.7.12 Proposition 98 Transfer to Education- Test 3

IGT('LSK14', 'CGENF') =E= IGT0('LSK14', 'CGENF') * ADA*((Y('CGENF') + SUM(, IGT(CGENF',G)))/SUM(H,HH(H)/ ((Y0('CGENF') + SUM(G, IGT0('CGENF', G))) / SUM(H, HH0(H)))

This rule is generally the binding constraint. The transfers from the general fund are maintained at a constant proportion of the general fund. Note that the terms after ADA are the ratio of general fund receipts (new equilibrium over old equilibrium).

If the general fund goes up ten percent because of the policy change then the ratio formed after ADA is 1.1. This implies transfers from the general fund to K thru 14 are 1.1 times the original transfer level.

IGT0('LSK14', 'CGENF') is initial transfers from the general fund to K thru 14 education.

ADA is one plus change in daily attendance. Here we assume no equilibrium growth so ADA = 1.

Y('CGENF') is the row total in the SAM for sector CGENF.

7.7.13 Public K-12 + Community College Spending

GSK14 =E= SUM(G, IGT('LSK14',G))

Spending on K through 12 + community college education is the sum of all transfers from government units to LSK14.

IGT('LSK14',G) is transfer payments from government units to LSK14.

7.7.14 Public University Spending

GSUNI =E= SUM(G, IGT('CSUNI', G))

Public university spending is the sum of transfers from all government units to CSUNI.

IGT('CSUNI', G) is transfers from government unit G to sector 'CSUNI'.

7.8 Model Closure

7.8.1 State Personal Income: Artificial Objective Function

SPI =E= SUM(H, (Y(H) + SUM(G, TP(H,G) * HN(H) *TPC(H,G)))

Maximize personal income: see earlier comments re objective function.

Y(H) is total household factor income.

TP(H) is per eligible household transfer payment.

HN(H) is number of nonworking households.

TPC(H,G) is fraction of nonworking households receiving transfer payments.

7.8.2 Labor Market Equilibrium

SUM(H,ALPHALS(H, L)*HW(H))/JOBCOR(L)=E=SUM(Z,ALPHALD(Z, L)*FD('LABOR', Z))

FD('LABOR', Z) is labor demand by sector Z.

JOBCOR(L) = SUM(H, ALPHALS(H,L) * HW0(H)) / SUM(Z, ALPHALD(Z,L) * FD0('LABOR',Z))

This corrects for difference between reported labor working (labor demand) and number of working households (from FTB data).

ALPHALD(I,L)$SUM(LL, ALPHAL(I,LL)) = ALPHAL(I,L) / SUM(LL, ALPHAL(I,LL)). ALPHALD(I,L) is the imposed share of labor type by industry sector (i.e., the fraction of industry I's labor that is type LL labor).

ALPHALS(H,L) = ALPHAL(H,L) / SUM(LL, ALPHAL(H,LL)). ALPHALS(H,L) is the imposed share of labor type by household type (i.e., this is the fraction of household type H that supplies type 'L' labor). We get data from FTB.

ALPHAL(H,L) is the number of households among a given type (e.g., type h) that supply type ‘L’ labor.

Each household has a unique type by both income level (indexed by h) and labor type (indexed by L) unless it is nonworking. SUM(LL, ALPHAL(H,LL)) is the total labor supply of all types supplied by household type H.

7.8.3 Capital Market Equilibrium

KS(I) =E= FD(‘CAPIT’)

Quantity of capital supplied equals quantity of capital demanded, by type.

7.8.4 Goods and Services Markets Equilibria

DS(I) + M(I) =E= DD(I) + CX(I)

Quantity supplied equals quantity of domestic demand plus net exports.

DS(I) is domestic production of I goods.

M(I) is imports of I goods.

DD(I) is domestic demand for I goods.

CX(I) is export of I goods.

7.8.5 Definition of Domestic Demand

DD(I) =E= V(I) + CH(I) + CG(I) + CN(I)

Domestic demand, by type of good or service, is defined as intermediate demand: V(I), plus household demand derived from composite commodities: CH(I), plus government demand: CG(I), plus investment demand: CN(I).

7.9 Not constraints, but efficient

Note: These are used in lieu of constraints as they are more efficient computationally.

7.9.1 Set PIT for Non-Income Tax Government Units to Zero.

PIT.FX(G,H) $ (NOT GI(G)) = 0

7.9.2 Set Inter-Governmental Transfers to Zero, if not in the Original SAM.

IGT.FX(G,G1) $ (NOT IGTD(G,G1)) = 0

7.9.3 Set Exogenous Inter-Governmental Transfers to the 2000-01 Budget Level

IGT.FX(G,G1) $ (IGTD(G,G1) EQ 2) =IGT0(G,G1)

7.9.4 Set Government Demand for Goods and Services to Zero, if not in Original SAM

GSP.FX(GG$(NOT SUM(G, SAM(I,G))) = 0

7.9.5 Set Factor Demand to Zero, if not in Original SAM

FD.FX(F,Z) $ (NOT SAM(F,Z)) =0

7.9.6 Set Government Rental Rate for Capital

R.FX(‘CAPIT’, G) = RO(CAPIT’, G)

7.9.7 Set Exogenous Transfer Payments

TP.FX(H,GW) =TP0(H,GW)

7.9.8 Set Transfer Payments to Zero, if not in the Original Data

TP.FX(H,G)$(NOT TP0(H,G)) = 0.